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The Semantics and Acquisition of Time in Language

Laura Wagner
University of Pennsylvania

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Abstract
This dissertation is about the structure of temporal semantics and children's acquisition of temporal language. It argues for the importance of investigating semantics both at the abstract level of linguistic structures and at the concrete level of the time-course of acquisition, as these two levels provide natural constraints for each other. With respect to semantics, it provides a computationally inspired analysis of tense, grammatical aspect and lexical aspect that uses finite state automata to dynamically calculate the progress of an event over a time interval. It is shown that the analysis can account for many well-known temporal phenomena, such as the different entailments of telic and atelic predicates in the imperfective aspect (the imperfective paradox), and the various unified and serial interpretations of sentences involving a cardinally quantified phrase, such as *Three Ringlings visited Florida*. With respect to children's acquisition of temporal language, the dissertation investigates the Aspect First hypothesis which states that children initially use tense and grammatical aspect morphology to mark the lexical aspect property of telicity. Two forced-choice comprehension experiments were conducted with children aged 2.5 to 5 years old to test children's understanding of tense and grammatical aspect morphology; in a control condition, open class cues were used to test children's conceptual competence with tense and grammatical aspect information independently of their competence with the relevant morphology (e.g., *in the middle of* and *in a few seconds* were the open class cues for imperfective aspect and future tense, respectively). Results showed that even the youngest children understood the concepts underlying tense and grammatical aspect as measured by their performance with the open class cues but they did not demonstrate adult competence with the closed class morphology for grammatical aspect and did so only marginally for tense. Comprehension of tense morphology preceded that of grammatical aspect morphology and in particular, children showed an early facility with markers of the future tense.

Comments
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THE SEMANTICS AND ACQUISITION OF TIME IN LANGUAGE

Laura Wagner

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ABSTRACT

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Laura Wagner

Lila Gleitman and Robin Clark

This dissertation is about the structure of temporal semantics and children's acquisition of temporal language. It argues for the importance of investigating semantics both at the abstract level of linguistic structures and at the concrete level of the time-course of acquisition, as these two levels provide natural constraints for each other. With respect to semantics, it provides a computationally inspired analysis of tense, grammatical aspect and lexical aspect that uses finite state automata to dynamically calculate the progress of an event over a time interval. It is shown that the analysis can account for many well-known temporal phenomena, such as the different entailments of telic and atelic predicates in the imperfective aspect (the imperfective paradox), and the various unified and serial interpretations of sentences involving a cardinally quantified phrase, such as *Three Ringlings visited Florida*. With respect to children's acquisition of temporal language, the dissertation investigates the Aspect First hypothesis which states that children initially use tense and grammatical aspect morphology to mark the lexical aspect property of telicity. Two forced-choice comprehension experiments were conducted with children aged 2.5 to 5 years old to test children's understanding of tense and grammatical aspect morphology; in a control condition, open class cues were used to test children's conceptual competence with tense and grammatical aspect information independently of their competence with the relevant morphology (e.g., *in the middle of* and *in a few seconds* were the open class cues for imperfective aspect and future tense, respectively). Results showed that even the youngest children understood the concepts underlying tense and grammatical aspect as measured by their performance with the open class cues but they did not demonstrate adult competence

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Chapter 1. Introduction

> *Our ordinary language shows a tiresome bias in its treatment of time. Relations of date are exalted grammatically as relations of position, weight, and color are not. This bias is of itself an inelegance, or breach of theoretical simplicity.*
>
> W.V.O. Quine, *Word and Object*, (§36)

This dissertation is about the structure of temporal semantics and children's acquisition of temporal language. The semantic and acquisition approaches have different focuses and use very different methods but both are needed for a deep understanding of time in language. Acquisition evidence is the limiting factor in all linguistic work, temporal semantics included. Whatever else we know about language, we know that it must be acquired by real children in real time. Any semantic model which does not constrain the child's learning problem, or which cannot account for the actual course of linguistic development, is not the right model. On the other hand, any investigation of children's language acquisition which is not informed by an explicit theory of what is to be acquired is certain to miss important insights. Imagine trying to study how children acquire arithmetic without an explicit model of how arithmetic is structured: there would be no way to differentiate between a child who incorrectly thought that 2+2 = 5 and one who incorrectly thought that 2+2 = 22. Similarly, children's competence with temporal language cannot properly be assessed without an explicit characterization of the semantic structures languages use to encode temporal concepts. Thus, the acquisition evidence constrains the formal analysis, which in turn informs the acquisition investigation.

Since the primary concern here is semantics (its structure and acquisition), it is worthwhile to begin with a brief discussion of what I mean by semantics. There are three levels that are relevant to consider: language, mind, and world. We can use evidence from the linguistic level to tell us something about how a semantic domain is structured -- how many

different categories does a language recognize and how are these categories related? For a variety of semantic domains (particularly those related to the physical world) language provides a level of rich structural interpretation, at which a limited number of categories are identified and related algebraically (Talmy, 1988). The temporal domain, as we shall see, is such a semantic domain. Temporal semantics consists not only in the linear ordering of elements in time, but also in the temporal properties of the things which get ordered, namely events. Thus the linguistic structuring of time operates over concepts such as completion, termination, and ongoingness, in addition to the ordering concepts of anteriority and simultaneity. (A detailed description of temporal phenomena in language will be provided in Chapter 2.) Because of this complexity, there is much to be learned simply by understanding the structure of temporal semantics, but this is not, of course, all there is to know about our understanding of time. Semantics may be structured, but it is also about things. That is, although it is useful to know, for example, that a cat bears the same relationship to a kitten that a dog does to a puppy, we also want to know what a cat, a dog, a kitten and a puppy are. The understanding of time and events per se or their properties is outside of the temporal structure; it is what the structure is about.

The relationship of language to mind, therefore, is a subset relationship. What linguistic semantics expresses represents a subset of what we know about that semantic domain; we always know at least one thing more than the semantic structures provide, namely, what those structures are about. Acknowledging this subset relation can also prevent us from falling into the Whorfian trap (cf. Whorf 1956, and perhaps even Jackendoff 1990, 1998) of believing that the way language structures a semantic domain determines the way our minds structure it. Having already conceded that the mind conceives of more than the semantic structures, it should come as no surprise that we conceive of concepts differently from the way our language structures them. For example, the mass/count distinction is an important element in the linguistic structuring of objects (via nouns). The difference

between mass and count nouns at the conceptual level is that count nouns consist of discrete units (one chair divided in two destroys the chair) while mass nouns are homogeneous (a portion of water divided in two yields two portions of water). Although language may structure water as a homogeneous entity, we don't have to. We can conceive of water as composed of discrete units, namely molecules of H_2O, and can believe that dividing a single molecule in two destroys the water leaving behind only some hydrogen and some oxygen.

This argument points to the third level relevant to semantics, the world. As can be seen from the water example, linguistic structures do not necessarily make the best models of the world. The world, moreover, does not in and of itself constitute a reasonable model of our semantics. As Quine (1960) noted, the world radically under-determines the possible descriptions of it -- the world provides a rabbit every time it also provides un-detached rabbit parts. Our language, however, distinguishes between these two things and so should our semantics. Moreover, with respect to temporal semantics, many of the elements which structure these semantics have no objective correlate in the world. One salient distinction in temporal semantics is the temporal perspective a speaker takes on an event (the imperfective-perfective distinction) and that is not a piece of information that is provided by the world. The general problem here is one of construal. The world is what it is but our understanding of it is mediated by a mental filter which imposes an interpretation on it. The properties of this mental filter are of enormous interest, of course, but their study relates only tangentially to a proper study of semantics. This isn't to say that the world is irrelevant to semantic investigation: the mental concepts which ground the linguistic structures must themselves be grounded solidly in the world if they are to be of any use to anyone, and in the end, our semantics are only as good as the validity of the information they give us about our world.

A good model of temporal semantics must be responsible to these semantic levels: it should capture the structure of temporality in language itself and also link those structures to

actual components of time in the world (as mediated by our mental conception of those components). In addition, the model should be sensitive to the uses to which we put our temporal semantics, in particular, to the fact that temporal semantics contributes to our reasoning about time and to the fact that we produce and comprehend temporal semantics on-line and finally to the fact that the linguistic encoding of these semantics must be learnable. The first of these facts will fall out in part in any model which is truly responsible to our conception of time in the world but all three facts rely on having a model which is computationally tractable. That is, a good model of temporal semantics is one that we, as human information processors, can use. A formal model of temporal semantics which attempts to meet these high standards will be presented in Chapter 3. The model has wide coverage of the linguistic structures of temporal semantics and links to the world by operating over the events actually happening during a given time interval; the evaluation of what in fact is happening is the point where mental construal (represented here by the Hold function) mediates between the world and linguistic structure. Moreover, the core of the model is constructed out of finite state automata, insuring a strong standard of computational simplicity.

One of the most important uses for the model is, of course, to provide a starting point for the acquisition of temporal language. There are two components to the language acquisition process: there are the parts of language which must be learned (such as language specific vocabulary) and the parts of language which come as part of our innate language capacity (Chomsky's Universal Grammar). The structure of temporal semantics is part of our innate capacity and therefore the model itself is not what needs to be learned. The motivation for this claim comes from two sources. The first is the apparent universality of temporal semantics. Cross-linguistic investigations (Dahl 1985, Bybee et al. 1994, cf. also Smith and Weist 1987) have documented a strong consensus among very different languages about what temporal categories are relevant to language and about how those categories

interact with each other. Universality alone does not guarantee innateness, of course, but innateness should guarantee universality; finding cross-linguistic consistency of temporal systems is therefore an important part of this claim. The second motivation for treating the temporal structures as innate is the apparent impossibility of learning them (or the concepts they depend on). Fodor (1975, 1981) has argued that concept acquisition in general cannot depend on learning because the tools needed to learn a new concept already implicate the presence of that concept in the first place. Consider a basic temporal concept like pastness. Learning about pastness would seem to depend on having a concept of the linear ordering of time, but a child who already understands that must already have the concept of pastness since pastness is implicated by the presence of the linear order. The temporal semantic structures of the model articulate a subset of basic relationships which exist among temporal concepts; since the concepts themselves cannot be learned, it seems plausible that structures of their relations would not be either.

What does need to be learned is the way that particular languages encode the temporal information contained in the model. The acquisition problem for the child is therefore a mapping one: she must learn how to map her semantics onto the morphology of the language she is learning. Having reduced the acquisition problem to the mapping problem does not trivialize the problem the child faces. Languages vary widely in how they grammaticize their temporal semantics and the child must determine the proper mapping in a very short time with no explicit instruction. Chapter 4 discusses the nature of the mapping problem and reviews evidence from children's production data that suggest children's initial solution to the problem may not be the correct one. Children's early competence with temporal semantics is investigated experimentally in Chapter 5 through two experiments focusing on children's comprehension of tense and grammatical aspect.

One of the themes that recurs in these acquisition chapters is the relationship between children’s conception of time and their competence with the linguistic structures of

time. Although I am assuming that the temporal semantics is not learned, it is possible that the semantic structure themselves undergo some form of development and very young children may not possess a complete set of structures. If this is true, the development of the semantics would not result from a learning process (for the reasons noted above) but from maturational or other biological processes. That is, the development of the temporal semantics would be distinct from the acquisition process per se, although, if the development happened late enough, it could interact with the language learning mechanisms. The experiments reported in Chapter 5 address this issue by comparing children's comprehension of temporal semantic concepts (i.e., their knowledge of the model per se) with their comprehension of temporal language (i.e., their knowledge of the linguistic mapping to the model).

As Quine (1960) noted in the quote which begins this chapter, time holds an exalted place in the grammatical systems of language: all languages mark temporal information grammatically to some degree (Dahl 1985, Bybee et al. 1994, Comrie 1976) and time is among the first elements to be grammaticized in the development of creole languages (Bickerton 1981, Bakker et al. 1995). I disagree with Quine, however, that such an emphasis represents an inelegance in language. Time is one of the few dimensions of the world critical to human experience: temporal location is a particularly valuable piece of information if one wants to distinguish between, for example, memories and future plans. The investigation of time in language presented here will at every turn re-affirm the importance of time not only for understanding the structures of our language but for understanding the world around us.

Chapter 2. Time in Language

2.1. Events in Time

Situating an event in time requires two kinds of information. First, it requires identifying simply when in time the event happened: is it happening at this very moment? at 5pm yesterday? three years ago on a Sunday morning? Second, it requires specifying how in time an event happened. Events are not instantaneous elements and even the shortest of events (such as blinking) transpires over an interval of time. It is necessary to know, therefore, how an event uses that time interval. The first kind of temporal information (when the event happens) corresponds to a fairly intuitive notion of past, present, and future, but the second kind of information (how an event happens) requires a bit more explanation.

The following sentences (1) and (2) describe two similar but distinct events.

(1) The chicken ran around in the road
(2) The chicken ran across the road

Let us assume that the two events take place over the same time interval. The difference between these two events comes in large part from the difference in the way the two events develop over that time interval. Although the two events may by indistinguishable through most of the time interval (both events involve a chicken, a road, and some running) by the end of the interval, the event in (2) leads to the chicken being across the road while (1) does not.

The progress of the events in these sentences is more or less constant throughout the time interval, but the way an event gets smeared over a time interval can become more complicated. Consider the following sentence:

(3) PT Barnum drank 3 beers from 8pm to 9pm.

As with sentence (2) above, we can be sure about the endpoint of the event in (3), in this case that by the end of the time interval (i.e. 9pm) the 3 beers will have been drunk, but surely the drinking was not a constant process. Barnum may eat some pretzels at 8:15 and pause to order his third round at 8:45 without falsifying the sentence. We can imagine scenarios in which (3) happens as a constant process (e.g., Otto Ringling is standing over Barnum and slowly and constantly drizzling the beer into Barnum's mouth) but the most normal interpretation is one which treats each beer drunk as a discrete sub-event and permits various interruptions to the drinking process.

This can be contrasted with a sentence like (4), which is like (3) in involving an iterated sequence of the same event (here we have a sequence of hops instead of a sequence of beer-drinkings) but is more similar to (1) and (2) in terms of the constancy of the event (that is, we are less tolerant of interruptions of the hopping).

(4) Barnum was hopping for an hour.

As we shall see in this chapter, there is systematicity to the way language expresses how an event gets smeared over a time interval and also to the semantic entailments of different smearings. Linguistically, such information is conveyed through the lexical aspect and grammatical aspect systems. Information about when an event happens in time is conveyed through the tense system. This aim of this chapter is to provide a general descriptive introduction to the semantics and basic linguistic encodings of lexical aspect, grammatical aspect, and tense.

2.1.1. Defining the Time Line

Before leaping into a description of how language situates events in time, it is necessary to say what I mean by time. In all of the following discussion I will consider time to be (1) composed of intervals, so there are no points in time, only intervals which may be quite small; (2) dense, so there is no smallest interval because density requires that each interval be able to be broken into smaller sub-intervals; and (3) flowing in a directed fashion such that temporal relationships of precedence and sequence can be specified between any two intervals. These properties will be discussed more fully in Chapter 3 but overall, this characterization corresponds well with our basic intuitions about time.

2.2. Lexical Aspect

Lexical aspect is a way of describing properties that predicates have that are relevant to the way they use up a time interval. It does not include all the temporal properties that events in the world actually possess but only those which operate systematically within language. A taxonomy of these properties (which is apparently similar to the one proposed by Aristotle) was articulated by Vendler (1967) and a battery of linguistic tests to support this classification scheme was contributed by Dowty (1979). This taxonomy relies on distinguishing between three essential properties: stativity (or the state-process distinction), telicity (or boundedness), and durativity. Further refinements of this taxonomy have been proposed by a variety of researchers (Moens 1987, Mourelatos 1981, Smith 1991, Olsen 1995 inter alia) but all have preserved the basic structure of the Vendler/Dowty system[1]. This basic taxonomy, along with the linguistic terms and associated properties is shown in Table 1. One current approach to lexical aspect focuses on its connection to nominal properties, such as the property which distinguishes mass and count nouns (cf. §2.2.5). This

[1] Though see Klein 1995 for a somewhat different conception of these properties.

approach requires some re-thinking of the Vendler/Dowty taxonomy but, as we shall see, is still largely compatible with it.

Table 1: The Vender/Dowty Taxonomy

Term	Features	Examples
State	+stative	know, own
Activity	-stative +durative, -bounded	juggle, sing, run
Accomplishment	-stative +durative, +bounded	build a house, sing a song, cross a high-wire
Achievement	-stative -durative, +bounded	win a race, reach the top
Punctual	-stative -durative, -bounded	crack a whip, sneeze, hiccup

This section discusses the three properties that underlie the Vendler/Dowty system (stativity, durativity and telicity) including several tests that distinguish among them, and addresses the relationship between these properties and the mass/count distinction in the nominal domain.

2.2.1. Stativity

The intuitive difference between a state and its opposite, a process, is that states ascribe properties[2] for the time in which they hold and processes are events proper which describe some form of change in time (Vendler 1967, Mourelatos 1981). A formal property which distinguishes between states and processes is the subinterval property, stated in (5) which is characteristic of states.

(5) SUBINTERVAL PROPERTY: for a predicate P and an interval *i*,
if (P, *i*) is true, then $\forall i'$, $i' \in i$, (P, *i'*) is true

[2] Which explains why virtually all adjectival predicates, such as *be red* and *be happy*, are stative.

The subinterval property states that is a predicate is true of an interval then it must be true for every subinterval of that interval. That is, every sub-part of that event is itself a valid instance of the event, leading to a continuous interpretation of the predicate. Consider the examples in (6) and (7).

(6) a. Kenneth Feld owned the circus from 1973 to 1998.
b. Anna Eva Fay believed in spirits.

(7) a. Irvin Feld bought the circus in 1967.
b. Anna Eva Fay died in 1927.

Own and *believe* are stative predicates and in the sentences in (6) the owning and believing events are continuous. Suppose that (6b) is true from 1891 to 1913. Then, no matter how small an interval of time we take within those years to evaluate (6b), it will be true; at every possible time interval in those years, Anna Eva Fay believed in spirits. The predicate is not so much an event as a property ascription to Anna Eva Fay. *Buy* and *die* on the other hand are processes (both are in fact telic processes, which, as we shall see shortly, is no accident) and they do not possess the subinterval property. A buying event can be composed of many parts, beginning with an expression of interest in owning a circus and ending with a check. If we try to evaluate (7a) before Irvin Feld has actually signed the check, then (7a) is false even though we're in a time interval leading up to the point where (7a) would be true. The evaluation of telic processes depends on whether their end-point has been reached and any sub-part of such an event which does not include the endpoint is not a valid instance of the event.

Comparing states to atelic processes, however, raises some questions about the usefulness of stativity as a distinct property. Activities, or atelic processes, also obey the subinterval property, albeit only down to a limited grain size (that is, the minimal intervals of evaluation must be of some maximal size). States proper are continuous and there is no restriction therefore on how small the subintervals may be in evaluating states. Atelic processes exhibit the subinterval property only down to some maximal-minimal interval.

That is, if you try to evaluate an atelic process (8) over too small a slice of time, then the predicate won't hold -- if you evaluate a juggling event moment-by-moment, you may be able to say that the balls are in the air, but you can't reasonably apply juggling to each moment.

(8) The clown juggled the balls for 5 minutes.

However, once we grant these maximal-minimal intervals, atelic processes show the subinterval property with respect to them and thus share with states the same essential formal property. Thus, at the macro-level (i.e., at intervals larger than the maximal-minimal intervals) atelic processes and states are indistinguishable while at the micro-level (i.e., at intervals up to the maximal-minimal intervals) atelic processes are equivalent to telic processes: each maximal-minimal interval defines a naturally bounded sub-unit of the atelic process[3].

Another property that has been proposed to distinguish states from processes is the fact that states do not appear naturally in the progressive. that is, the states in (9) sound decidedly more awkward than those in (10).

(9) a. ?Feld was owning the circus.
b. ?Fay was believing in spirits.

(10) a. Feld was buying the circus.
b. Fay was dying.

The awkwardness in the progressive, however, is a weak test for stativity because it is not true of states of position and location (11), although these predicates clearly pattern with other states with respect to the subinterval property (i.e., they are true over arbitrarily small subintervals).

(11) a. Feld was lying on a bed of nails
b. Fay was sitting at a seance table.

[3] And in English, reference to the smallest units of atelic processes in fact appears to be handled by telic predicates. Thus walking (atelic) consists of units of taking a step (telic).

The progressive test appears to be more sensitive to the non-volitional character that most states have[4] and not to their temporal properties, and as it is the temporal properties which are of chief interest here, this issue will be put aside.

I will continue to use states as a descriptive term, but as we shall see in section 2.2.5 below, the aspectual taxonomy that I will be adopting essentially eliminates the distinction between atelic processes and states, grouping them together in opposition to telic and non-durative events.

2.2.2. Telicity

The term telicity is derived from the Greek *telos*, meaning end. Telic predicates are those which describe events that have a natural end-point or boundary. Atelic predicates may end at any arbitrary point in time[5]. This difference can be seen quite clearly in the kind of temporal adverbials each appears with most naturally. Atelic predicates appear naturally with *for X time* adverbials, where the adverbial serves to define the time limit on the event. Telic predicates on the other hand appear naturally with *in X time* adverbials, where the adverbial serves to line up the natural endpoint of the event with a particular time.

(12) Atelic
  a. ??The clown juggled in 2 minutes
  b. The clown juggled for 2 minutes

---

[4] The progressive patterns with other constructions which implicate volitionality such as the imperative and pseudo-clefts with *do*.

(i) a. ?? Believe in spirits!
  b. ?? What Feld did was own the circus
(ii) a. Buy the circus!
  b. What Anna Eva Fay did was die

Moreover, The case marking systems of some languages (e.g. Oneida) support the stative/non-volitional connection: states and processes differ in some instances with respect to their subject case marking such that the subjects of processes get nominative (or agentive) case and the subjects of states get accusative (or patientive) marking (Michelson 1991, Palmer 1994).

[5] As we shall see shortly, telic predicates may also end at any arbitrary time, but when they do, they suffer a loss of entailments. Cf. the imperfective paradox.

(13) Telic
a. Wallenda crossed the high-wire in 2 minutes
b. ?? Wallenda crossed the high-wire for 2 minutes

It is of course possible to combine the adverbials with event types in a non-natural fashion and such non-natural pairings yield systematic interpretations (cf. Moens 1987 and Moens and Steedman 1988). Combining telic predicates with *for X time* produces much the same effects as combining these with the progressive (see below): they lose their entailment of completion. Thus, (13b) above has an interpretation in which Wallenda was working at crossing the high-wire for 2 minutes, though he may never have actually crossed it completely. When the adverbial *in X time* is combined with an atelic predicate, the usual interpretation is that the specified time denotes the time one has to wait until the event begins. Thus, (12a) above has an interpretation in which the juggling started 2 minutes after some other salient event (e.g., *The clown did a handstand and then, in 2 minutes, she juggled*).

The imperfective (i.e. the progressive in English) has different effects when combined with telic and atelic predicates, leading to the so-called imperfective paradox (cf. Dowty 1979 and Landman 1992 among others). With an atelic predicate, the imperfective form entails the perfective (and even the perfect) form of the sentence (i.e., 14a entails both 14b and 14c). With a telic predicate, however, the imperfective form does not entail the others (i.e., 15a does not entail 15b and 15c).

(14) Atelic
a. The Ringling Brothers were visiting Baraboo
b. The Ringling Brothers visited Baraboo
c. The Ringling Brothers have visited Baraboo

(15) Telic
a. The Ringling Brothers were building their winter quarters in Baraboo
b. The Ringling Brothers built their winter quarters in Baraboo
c. The Ringling Brothers have built their winter quarters in Baraboo

The generalization is that telic predicates lose their entailment of completion in the imperfective (atelic predicates have no such entailment to lose). This can perhaps be seen

more clearly by noting that the continuation in (15d) is good if it follows (15a) with the telic predicate in the imperfective but bad if it follows (15b) or (15c) with the telic predicate in the perfective and perfect (where the completion entailment goes through).

(15) d. ... but they never finished them and moved to Florida instead.

Telic and atelic predicates also yield different interpretations when combined with the modifier *almost*. An event of almost-running (atelic predicate) means that no running took place (16); an event of almost-crossing (telic predicate) however can negate either the event itself (as in the atelic case) or simply the completion of the event. Thus (17) has two possible interpretations: the crossing event may never have started in the first place (cf. the first continuation) or it may have started, but not reached its completion point (cf. the second continuation).

(16) The clown almost ran after the tiger
... but she thought better of it and didn't start

(17) Wallenda almost crossed the high-wire walking on her hands
... but decided it was too dangerous and didn't start
... but fell half way across

2.2.3. Durativity

Durativity refers to how long (in a very subjective sense) an event lasts in time. For example, consider the following two telic sentences.

(18) Wallenda reached the platform
(19) Wallenda crossed the high-wire

Both sentences have the same natural end point: when Wallenda is at the platform. The difference is that in (18) Wallenda begins the event a split second before the platform while in (19) she begins the event at the opposite side of the high-wire. In the world, of course, both events do have a duration (through presumably the duration of the event described by (18) is much shorter than that described by (19)); linguistically however, (18) is considered to

have no duration, or at least, to have the absolute minimal duration. This linguistic lack of duration can be seen by the fact that non-durative predicates occur naturally with *at X time* adverbials which pin-point a particular time:

(20) a. Wallenda reached the platform at 5pm precisely
b. Gunther cracked his whip at the moment the lion roared

Nondurative predicates also have characteristic interpretations in the imperfective (progressive). Non-durative predicates that are also telic (achievements) generally focus on a preparatory state with a concomitant loss of the entailment of completion; non-durative predicates that are also atelic generally yield an iterated interpretation (cf. Moens 1987 and Moens and Steedman 1988 for an extended discussion of non-durative interpretations in the imperfective[6].). For example, the non-durative atelic sentence in (21) is understood as involving repeated hiccoughs and the non-durative telic sentence in (22) is interpreted as referring to the process leading up to the reaching event.

(21) The ringmaster was hiccoughing
(22) Wallenda was reaching the edge

2.2.4. Composing Lexical Aspect

Lexical aspect, despite its name, is not a property of individual lexical items. The aspectual value of a predicate is determined compositionally, with the verb, its arguments, and sometimes even adjuncts in the sentence contributing information. For example, intransitive *sing* in (23a) is atelic, but transitive *sing* has a telic interpretation (23b).

(23) a. Jenny Lind sang (for an hour/#in an hour)
b. Jenny Lind sang "America the Beautiful" (#for an hour/in an hour)

[6] The interpretative shift that a particular sentence undergoes is largely a pragmatic function. For example, a video-tape of a hiccoughing event (atelic, non-durative) played in slow motion might yield a preparatory interpretation instead of the more common iterated reading.

Events are telic when they have a natural end-point and end-points are often defined by the change that an argument goes through. Using Tenny's (1987) terminology, arguments are used to MEASURE OUT an event leading to a referential transfer of the properties of the argument onto the event as a whole (cf. also Dowty's (1992) INCREMENTAL THEME, Krifka's (1992) MAPPING TO OBJECTS/EVENTS and Jackendoff's (1997) extended discussion of the conceptualization of measuring out). Thus, in (19b), the event as a whole progresses in lock-step with Jenny Lind's progression through the song -- as more of the song has been sung, more of the event has occurred. The transfer is total so that the end of the singing event corresponds precisely with the end of the song "America the Beautiful". In (23a) where there is no object to measure out the event, the event remains unbounded and atelic[7].

In order for objects to define limits, they must be of the right sort: the sentences in (24) and (25) both have direct objects but only (24b) and (25b) are telic.

(24) a. Juliet drank water.
b. Juliet drank a tub of water.

(25) a. Juliet ate peanuts.
b. Juliet ate a peanut.

The generalization exemplified here is that count noun objects can measure out a telic event while mass nouns and bare plurals cannot[8]. (This distinction is captured by Verkuyl's Specified Quantity of A property (a predicate must have a +SQA object in order to be telic) and Krifka's structuring of quantized (count) elements vs. his cumulative (mass) elements.) In some languages, the ability of an object to measure out an event is marked by case. For

[7] It is possible to separate the event from the measuring out of the object. In sentences with cardinally quantified objects (a) there are many ways to transfer the object reference to the event -- ranging from a single event involving 4000 ships sailing at once to 4000 events, each involving a single ship (and any combination in between).

(i) 4000 ships sailed through the lock (from Krifka 1990)

[8] Subjects must also have the right properties as well. Sentences with bare-plural subjects often receive an atelic interpretation (ii) though with a count noun subject the sentences would be telic (i).
(i) The owner has discovered the Russian balancing act.
(ii) Circus goers have been discovering the Russian act (for years)
The influence of the subject on telicity seems to interact strongly with genericity in the sentence.

example, in Finnish, verbs which may take either accusative or partitive case on their objects differ in their telicity properties depending on which case is used (Krifka 1990, Heinämäki 1984). Thus, (26a), with accusative case, is telic while (26b), with partitive case, is atelic (examples from Krifka 1990).

(26) a. John söi kalan
J. ate fish-acc
"John ate a fish"

b. John söi kalaa
J. ate fish-part
"John was eating a fish; John ate of a fish"

Canonically, direct objects are the means of measuring out events. This fact has led several researchers (Tenny 1987, Van Hout 1996, Verkuyl 1993; see also Dowty 1992) to link the notion of telicity to transitivity. They argue that while not all transitive sentences are telic (27), all telic sentences have a logical direct object. That is, in (28), Anna is really the object of dying as the dying happens to her. Such an analysis depends in part on the validity of the unaccusative hypothesis (Perlmutter 1978, Belletti and Rizzi 1988), which states that the subjects of certain intransitive verbs are underlyingly objects and gives the analysis in (28b) for (28a).

(27) The trainer pushed the dog.

(28) a. Anna died.
b. Anna_i died t_i

The existence of examples like (27), in which the object does not serve to measure out the event despite its well quantified nature, is somewhat problematic because it requires these verbs to be idiosyncratically marked as exceptions to the general pattern. Verkuyl (1993) has argued that the verbs which show this property of remaining atelic even with a count noun direct object, the so-called push-class, form a coherent semantic class[9]. He claims that

[9] Other verbs in this class include *stroke, torture, turn, rub, caress, paint, mow,* and *drive*. Note that some of these verbs always display push-type behavior (i.e., resistance to telicity given the right kind of direct object) while some allow a construal that is telic when they appear with a direct object (e.g., *mow*).

the direct objects of these verbs are more like indirect objects semantically. Thus, *push the dog* may be paraphrased as *give a push to the dog* where *the dog* ends up explicitly as an indirect object; non push-class verbs do not allow this alternation (e.g., *build the house* cannot be paraphrased as *give a build to the house*). Finding a semantic basis for this class of exceptions is certainly desirable, but it is unclear that such a creative re-analysis of these sentences is the solution to the problem, at least in English. Note that verbs in this class do combine with resultative predicates and directional prepositional phrases to form telic predicates.

Despite the special relationship between verbs and objects, telicity can be measured out through other means, in particular, by certain prepositional phrases and by contextual knowledge. Jackendoff (1997; see also Smith 1991) has systematically described the aspectual effects of PP's. He points out that like objects, paths can also measure out an event and paths are generally expressed through PP's. Thus, in (29), we see the same contrast as in (24) and (25): with a PP measuring out the event, (29b) is telic but without that path information, (29a) is atelic.

(29) a. The train chugged (for an hour/#in an hour)
b. The train chugged to Chicago (#for an hour/in an hour)

And, just as the properties of direct objects affect the telicity of the predicate, so too the properties of the PP influence whether a predicate is telic or not. Directional PP's, with prepositions such as *to, up, down*, and *over* make a predicate telic (29). Conative PP's (i.e., prepositions which are used in conative and similar constructions), with prepositions such as *at* and *towards*, make a predicate atelic. The effect of the conative PP can be seen in (30) and the contrast between the two classes can be seen in (31).

(30) a. Er braute ein Haus.
he built a house
"He built a house"

b. Er braute an einem Haus.
he built at a house
"He was building a house; he built part of a house"

(31) a. I ran to the circus (in 10 minutes)
b. I ran toward the circus (for 10 minutes)

Contextual knowledge can also contribute to aspectual composition (cf. Moens and Steedman 1988, Olsen 1994). For example, if both speaker and hearer know that Otto is in the habit of running a mile each day, then it is possible to say (32) and get a telic interpretation.

(32) Otto ran (in only four minutes!)

Notice that paying attention to the way that objects or other elements measure out an event highlights an additional difference between telic and atelic events. The measuring-out process gives telic events an internal temporal structure that is absent from atelic events. That is, in order to drink a tub of water it is necessary for the water level to decrease in a regular fashion -- you cannot drink the middle third of the water in the tub first. More complexly, in order to build winter quarters it is necessary not only to engage in relevant building activities, but to engage in them in the right order: the roof can be put on only after the walls have been built and the walls can go up only after the foundation has been poured. Such structure contrasts with an atelic event like juggling which, once the maximal-minimal interval has been identified, has nothing further to say about the internal structure of the event. These structuring properties have sometimes been treated as something the linguistic system should be accountable for (e.g., Krifka 1992, Jackendoff 1997) but there are good reasons to relegate them to extra-linguistic knowledge. Primary among these reasons is language's flexibility in describing unusual situation. For example, if I am able to use magical powers when building a house, I might very well put the roof up before I build the walls; such a situation could be reasonably described as *I built a house* so long as the semantic entailments of the sentence were met (i.e., that there be a completed house at the end of the event). It

overburdens the linguistic system to make it encode world knowledge (such as the typical way to build a house) and it begs the question of how much world knowledge would have to be encoded (should language also encode the magical way to build houses?). I will return to these issues again in the following chapter (§3.4).

2.2.4.1. Composing Multiple Events

Whenever there is a cardinally quantified NP in an sentence (and the cardinality is greater than one) then it is possible to get a multiple event interpretation off the sentence. Consider the following examples:

(33) I went to the circus six times.
(34) Four women visited Philadelphia.
(35) Otto ate three cookies.

The sentence in (33) refers to six events of circus-going (in fact that is its only interpretation because the adverbial *N times* targets events explicitly), (34) may refer to four events of visiting (perhaps each woman went on a different day), and (35) may refer to three events of cookie-eating. Sentences (33) and (34) also have single event interpretations as well (e.g., all four woman visited together; Otto ate all three cookies in one gulp) but the cardinality of the NP's can transfer into the cardinality of the events.

This transfer can become quite complicated when there is more than one cardinally quantified element, as in (36) (example from Link 1998).

(36) Four men lifted three pianos.

This sentence permits interpretations involving as few as one event (when four men collectively lifted a set of three pianos all at once), as many as twelve events (when each of four men lifts each of three pianos in succession) and many combinations in between (e.g., two men lift one piano and two other men lift two pianos at once; three men lift a single piano and one man lifts two pianos in succession; etc.).

2.2.5. Events and the Mass-Count Distinction

It has been noted by several researchers (e.g. Krifka 1990, Bach 1986, Mourelatos 1982, Link 1998) that there is an interesting connection between telicity within the event domain and the mass/count distinction within the nominal domain. Not only do count objects contribute to telic events and mass objects to atelic events compositionally as noted above, but conceptually count nouns share properties with telic events (and mass nouns with atelic events).

Count nouns are things which can be separated into discrete countable units (cf. Quine's divided reference). The noun itself identifies the unit of counting. Thus, the counting unit of chairs is a chair. These counting units are minimal: splitting a chair in half will not give you more chairs. Within the event domain, telic events are also countable by means of their boundary points. We can count house-building events by the number of end-points (or houses) we have; we can count sandwich-eating events by the number of sandwiches ingested. Moreover, like count nouns, telic events also cannot be split and retain their identity: half of an event of house-building (or sandwich-eating) is not itself an instance of house-building (or sandwich-eating).

Mass nouns and atelic events work differently. For these two, taking a subpart of the whole does give you a viable example of the whole: half of a bar of gold is still a good instance of gold and half of an event of running is still a good running event[10]. The homogeneous structure of the mass/atelic examples also them from being properly counted because the whole is no different than the parts. As Quine (1960) notes, "any sum of parts

[10] Of course, even mass objects do bottom out: if you split a single atom of gold you no longer have gold and less than a millisecond of running probably isn't running anymore. But as was discussed in the introduction, this only serves to remind us that the ontology of our semantics rests on a very naive physics.

which are water is water". Only by imposing a boundary can these be counted. That is, we can count bars of gold or different bouts of running.

One way to see the parallelism between the telic/atelic and count/mass distinction is by their similar behavior with counting and amount expressions. Both telic event predicates and count nouns are fine with cardinal counters (37a and 37b)) while atelic event predicates and mass nouns are bad in these contexts (38c and 38d). The reverse pattern of acceptability is found when mass type amount quantification is used (examples in 37 and 38 are slightly adapted from Bach 1986's examples 1-4).

(37) a. John fell asleep three times during the night
b. Three dogs were in the yard
c. #John slept three times last night
d. #Three muds were on the floor

(38) a. #John fell asleep a lot last night
b. #Much dog was in evidence
c. John slept a lot last night
d. Much mud was in evidence

It is important to note that the sentences above with the symbol "#" are not ungrammatical, but simply don't have the relevant interpretation. As mentioned in §2.2.2, adverbials (and as we see here, quantifiers) pair naturally with certain events (or nominals) but lead to systematic interpretations when they are paired in a non-natural fashion. The basic rule for interpreting the non-natural pairings is that the semantic requirements of the quantifier/adverbial always win (Moens 1987, Moens and Steedman 1988, Jackendoff 1997, Smith 1991). The cardinal quantifier *three* can only be applied to countable elements so (37c) can be interpreted only if we can identify three units of sleeping (that is, an iterated interpretation) and (37d) requires us to construe *mud* as a count noun (that is, there are three kinds of mud on the floor). Similarly, amount phrases like *a lot* and *much* apply to durative events and substances respectively so (38a) requires a durative construal of fall asleep (again we get an iterated interpretation) and (38b) leads to an interpretation of *dog* as a mass noun (that is, doggy-stuff was in evidence). Note, however, that the parallelism between the two

domains persists in that both events and nominals can be coerced to their opposite valence along the telic/atelic or count/mass dimensions.

So far, I have characterized the mass-count distinction in the event domain as corresponding to the atelic-telic distinction, but this is not strictly true. The semantic distinction at issue here is really homogeneity of structure on the one hand and discrete countability on the other. This distinction forces a slightly different grouping of predicates than the Vendler/Dowty classification does. First, states and atelic processes (activities) are classed together as mass-atelic events based on their shared homogeneity of structure. Second, atelic non-durative events (punctuals) are classed as count-telic events, although this classification requires some explanation.

Punctual predicates such as *crack the whip* and *sneeze* pose a special problem for the mass-count based classification system offered here. Intuitively, these events do have a natural end-point and identify discrete events. However, when we apply standard tests like the *almost* test (discussed in §2.2.2), we find that they pattern with homogenous predicates in having only one reading. Sentence (39) indicates only that the event did not in fact begin.

(39) Gunther almost cracked the whip.

The problem with these non-durative predicates is that they are atomic in nature and therefore have no internal structure, either of a homogeneous or of a discretely countable nature. The discreteness of the atomicity makes these predicates seem count-like, but their lack of internal structure classes them with the homogeneous predicates -- they represent the limiting case where all parts of the internal structure are the same. This dual nature is a problem not just for atelic non-duratives but extends to telic non-duratives (achievements) as well. Sentence (40) has a clear result but still has only one reading with *almost*[11].

[11] Notice, however, that it's not the reading available for atelic predicates. In (40), the event is not completed, but it must have begun; this sentence entails that the Wallendas at least began to cross the high-wire.

(40) The Wallendas almost reached the edge of the high-wire

There are three possible ways to deal with these example: we can go with the intuition that atomic predicates are naturally bounded and class them with the count/telic events; we can develop a third category for atomic predicates; or we find a way to distinguish between the atomic predicates and class the punctuals with the mass/atelic events and the achievements with the count/telic class. One good candidate for distinguishing between the two kinds of non-duratives is the way they characteristically behave in the imperfective (cf. Moens 1987, Moens and Steedman 1988): atelic non-duratives typically receive an iterated interpretation in the imperfective while telic non-duratives expand to include their preparatory state (cf. §2.2.2). This difference suggests we can adopt the third route noted above (i.e., divide the non-duratives between the classes) but it turns out that a closer examination of iteration will lead us to class all non-duratives as being count-telic instead.

Any event which takes up a short duration relative to its evaluation interval may receive an iterated interpretation, regardless of grammatical aspect. Thus, all of the sentences in (41) have iterated readings, despite the presence of perfective aspect and the fact that (41a) is clearly non-atomic.

(41) a. I wrote/was writing my name for hours.
b. Mary won/was winning the marathon for many years.
c. I tapped/was tapping my fingers for a while.

Thus, iterated interpretations are not special to atelic non-durative predicates, or even to atomic predicates in general. In fact, the only kind of event which apparently cannot receive an iterated interpretation (without an explicit indication of iteration) is an atelic (durative) one[12]. Of the sentences in (42), only (42c) has an iterated interpretation, and that is by virtue of the explicit nature of the adverbial.

[12] And even with explicit indication, activities in the progressive get iterated interpretations only marginally.

(42) a. The clowns juggled/were juggling for hours
b. The lion ran/was running around for a while.
c. I danced/was dancing 3 times.

This fact, that durative atelic predicates cannot iterate without explicit notice, provides the clinching argument for the classification of the atelic non-duratives: they should be classed with all the other predicates which can iterate as being count-quantized.

Table 2 presents a summary of the above-discussed classifications showing how the features of stativity, telicity and durativity map onto the mass-atelic/count-telic distinction. I have also included commonly used terms for the different kinds of predicates which will provide a handy way to refer to the different classes.

Table 2: Comparison of Aspectual Classes

Aspectual Term	Properties -1	Properties -2	Examples
State	state atelic, durative	Mass/Atelic	believe own a circus
Activity	process, atelic, durative	Mass/Atelic	juggle, sing, run around eat pears, drink water
Accomplishment	process, telic, durative	Count/Telic	build a house, cross a wire eat a pear, drink a tub of water
Achievement	process, telic, non-durative	Count/ Telic	win a prize reach the edge
Punctual	process, atelic non-durative	Count/ Telic	hiccough sneeze, crack a whip

2.3. Grammatical Aspect

Grammatical aspect provides a temporal perspective on an event, situating one either inside an event or outside of it. The interior perspective corresponds to imperfective aspect (marked with the progressive *be + ing* in English)[13] and the exterior perspective corresponds to perfective aspect (conveyed through non-progressive forms such as the simple past in English). Intuitively, the semantic function of grammatical aspect is to provide a spotlight

[13] The progressive is a sub-type of imperfective and has a somewhat more restricted application. In particular, progressives (but not imperfectives in general) are usually restricted to process predicates.

on part of an event and make it more salient (Smith 1991, Klein 1994, Olsen 1994). Perfective aspect highlights the end of the event and keeps in shadow the processes leading up to the end. Imperfective aspect does just the reverse, highlighting the process at the expense of the endpoint[14].

Grammatical aspect is intimately related with lexical aspect but it is important to remember that it is a distinct linguistic element. While lexical aspect is a description of semantic properties already present in a predicate, grammatical aspect is an independent unit of meaning that is added to a sentence. Grammatical aspect is encoded through morphology in higher functional projections (IP or one of its exploded offspring) and languages commonly conflate grammatical aspect with tense (and other IP categories) morphologically (cf. Dahl 1985). The independence of the two kinds of aspect can be seen in their interaction effects: for example, the fact that telic predicates lose their entailment of completion in the imperfective or that non-durative predicates take on an iterated interpretation in the imperfective (perfective aspect participates in fewer interactions because its focus on the endpoint of an event requires events to run their natural course; however, as will be discussed below, perfective aspect does lead to an inceptive reading of stative predicates in some languages).

Analyses of grammatical aspect treat them as functions that operate over lexical aspect (Moens 1987, Moens and Steedman 1988, Klein 1994, Olsen 1995, Smith 1991) and

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[14] Smith 1991 has argued for the existence of a "neutral" grammatical aspect in addition. However, her arguments show at most that some forms (such as the simple present and future in French) are underspecificed with respect to their grammatical aspect and can be used in both a perfective and an imperfective way. Her strong claim about the neutral aspect being more than simple underspecification has to do with the conjunction of forms with different aspects (as in i). She claims that if the French future were really underspecified (instead of neutral) then it should be able to take on either the imperfective or perfective meaning at will and permit a conjunction like the one in (i). This is not allowed however, as can be seen by the fact that sentence (ii) is contradictory.

i. War was breaking out but it didn't break out.
ii. #La guerre éclaira mais elle n'éclaira pas.

However, this argument for the neutral viewpoint is far from compelling. It is entirely plausible that the French future is simply an underspecified form but that it can only be interpreted fully in one way per

essentially pick out the relevant piece of the event (either the end-point[15] or the process leading up to it). Some in addition (Klein 1994, Olsen 1995) link the output of the grammatical aspect function to tense (via the Reichenbachian reference point). Thus, the function of grammatical aspect is to isolate a piece of an event for temporal interpretation.

An alternative way to think about grammatical aspect is through the mass-count ontology: imperfective aspect creates a mass/cumulative interpretation and perfective aspect creates a count/telic interpretation (cf. Krifka 1992). From this perspective, the perfective aspect's focus on end-points is merely a reflex of its need for countable elements and similarly, the imperfective's ignoring of end-points reflects its need to eliminate countable points to keep the structure homogeneous. Moreover, this perspective suggests a natural link between perfectivity and telicity on the one hand and imperfectivity and atelicity on the other. We see this link manifested through so-called "definiteness effects" associated with grammatical aspect. For example, in a language like Czech, which has no articles, the form *víno* is ambiguous between meaning "the wine" and "wine" (bare noun). Thus, if such a noun appears as the object of a verb like *drink*, the sentence should in principle be ambiguous between a telic interpretation (*I drank the wine*) and an atelic interpretation (*I drank wine*). This ambiguity is clarified through the choice of grammatical aspect. When the sentence appears in the perfective (43a), the sentence is telic but when it appears in the imperfective (43b), it is atelic. Thus, the count/mass properties of the grammatical aspect marking bleed down onto the elements contributing the lexical aspect information (examples from Krifka 1992)[16].

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sentence (thus ruling out ii) or alternatively that ii is deemed a contradiction based solely on the repetition of the form *éclaira*.

[15] And as we shall see in §2.3.1., in some cases, the beginning point.

[16] Krifka has pushed an analogous line of argument to link partitive case marking in Finnish with progressive marking. His analysis seems to depend largely on cross-linguistic translation equivalencies. Sentences like (22b) in which the object has partitive case are generally translated with imperfective marking in languages which lack the partitive/accusative distinction found in Finnish. He argues from this that partitive case contributes progressive meaning; that is, that lexical aspect information bleeds up to the grammatical aspect level. However, while atelicity and imperfectivity are clearly linked, the Finnish data does not support this kind of strong link in which one actually determines the other. Heinämäki (1984)

(43) a. Ota pil víno
O. drank-imperfective wine
"Ota drank wine"

b. Ota vypil víno
O. drank-perfective wine
"Ota drank the wine"

2.3.1. Grammatical Aspect, Event Schemas, and Aspectual Verbs

Grammatical aspect markers may take somewhat more refined viewpoints than the simple imperfective and perfective perspectives. Events themselves follow a natural schema (cf. Moens 1987, Moens and Steedman 1988, Klein 1994): they begin, endure for some time, and end. If the event is resultative, then following the end-point is the consequential result state. This schema represents nothing more than our common-sense knowledge about how events happen in the world: beginnings happen before endings and consequences follow from the events which cause them. Grammatical aspect markers may make reference to each of these crucial points in the schema. Perfective markers make reference to the end-point and the imperfective markers to the enduring process.

Many languages have grammatical aspect markers that make reference to the result state of an event. One example of such a marker is the English perfect. For example, the perfect is awkward with atelic predicates (which have no end-point and therefore no result state) as well as with punctual predicates that have no result state (44a and 44b). Of course,

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provides an example in which a Finnish sentence contains both a partitive object and a bounding adverbial (i). In such a case, the natural translation consists of a perfective form and not the usual progressive.

(i) Maija luki kirjaa Helsinkiin saaka
M. read book-part Helsinki-to as far as
"Maiji read the book all the way to Helsinki"

A language like English does not have a direct equivalent of partitive case. Expressions exist which are close (e.g. *read from a book, read in a book, eat of an apple,*) but they don't sound as natural in English as the partitive does in Finnish. However, the fact that the most natural translation of partitive case is often the progressive in English does not mean that partitive case serves the same function in Finnish that the progressive does in English.

context (linguistic or extra-linguistic) can supply an end-point or a result state to predicates which lack them, but the perfect applies most naturally to telic predicates which already supply both (44c).

(44) a. PT Barnum has hopped.
b. The clock has struck the hour (from Moens and Steedman 1988)
c. The Wallendas have crossed the high-wire.

Mandarin Chinese appears to have several grammatical aspect markers that refer to result states. The morpheme *zhe* indicates that the result state is ongoing (45): the event is one of painting-hanging and the *zhe* marker indicates that the result state (of the painting being on the wall) is ongoing (Chan 1979, Smith 1991). Smith (1991) notes that English has an equivalent use of the imperfective with states of position (cf. the translation of (45)).

(45) Qiángshang gùa-zhe yiifú huua
On the wall hang ZHE a painting
A painting is hanging on the wall (Chan 1979[17])

Mandarin also has a marker, *guo*, which indicates that although a result state was reached, it no longer obtains (Smith 1991). Thus sentence (46) applies only after Zhangsan is no longer sick; *guo* indicates that the results of having fallen ill no longer obtains.

(46) Wo shuaiduan-guo tui
I break-GUO leg
"I broke my leg (it has healed since)" (Smith 1991)

In addition to focusing on result states, languages may also mark the beginning or inception of events. Russian (Comrie 1976, Smith 1991) has an inceptive prefix which marks the beginning of an event (47)[18].

[17] These examples come from papers using different transcription conventions. I will preserve the conventions used in those papers even though it means inconsistent conventions within this paper.
[18] It is somewhat misleading to address the Russian aspectual prefixes under the heading of grammatical aspect since they are part of what Slavacist's call Aktionsart (or lexical aspect). Like other grammatical aspect markers, these prefixes add perspective information to a predicate; however they do not have the same grammatical status that imperfective-perfective markers do in Slavic languages (e.g., sentences containing these prefixes must be marked for perfective-imperfective aspect in addition).

(47) pisat' to write
za-pisat' to begin writing

Some languages (e.g. Greek, Bulgarian) can combine the inceptive and resultative perspectives through their perfective marker. When the perfective marker is applied to a state which is naturally interpreted as the result state from some event, the perfective marker indicates inception into the result state, as can be seen in the Bulgarian examples in (48)[19]. This follows naturally from the standard event schema noted above: the end-point of an event (which the perfective marker highlights) is the point at which the event proper ends and the result state associated with the event begins. Thus the inceptive interpretations with the perfective follow from this dual role of the end-point of an event.

(48) a. Az obicah Ivan
I love-imperfective.past Ivan
"I loved Ivan"

b. As obiknah Ivan
I love-perfective.past Ivan
"I fell in love with Ivan"

Finally, Mandarin Chinese has a much discussed grammatical aspect marker indicating terminative aspect. The morpheme *le* (when it occurs immediately post-verbally, not at the end of the sentence) indicates that the event has terminated but is neutral with respect to whether the completion point was reached (if the event has one) (Chan 1979, Chu 1976, Smith 1991, Tenny 1994; but see also Li 1990). Thus the sentence in (49) may be followed by the completion in (50a).

(49) Wo syele yifeen syìn
I write -LE one letter,
"I wrote a letter" (Chu 1976)

(50) a. keshr méi sye-wán
but not write-finish
"but didn't finish it" (Chu, 1976)

[19] Thanks to Roumyana Izvorski for the Bulgarian example.

To insure the implication that the letter was finished, the sentence must contain a perfective marker in addition[20].

(42) b. taa xie-le liangfeeng xín le
he write-LE 2 letters perfective
"he has written 2 letters." (Chan 1979)

In essence, the Mandarin marker *le* means something equivalent to the aspectual verb *stop*, as can be seen in (51).

(51) I stopped writing a letter yesterday... because I just didn't know what to put in it

This connection between the grammatical aspect marker *le* and the aspectual verb *stop* is no accident: aspectual verbs, like grammatical aspect markers pick out pieces of the event schema. The aspectual verb *begin* picks out the inception of an event (as inceptive markers do) and *finish* refers to the completion of an event (as perfective, perfect, and resultative markers do). Aspectual verbs are not grammatical aspect markers themselves; unlike grammatical aspect markers, aspectual verbs are not functional elements and they are never obligatory. Nevertheless, they are one way that a language like English, which is relatively poor with respect to grammatical aspect markers, can convey the same meanings that other languages convey through grammatical aspect.

2.3.2. Grammatical Aspect in Multi-Clause Interpretations

So far, this discussion has been restricted to single clause sentences in isolation. However, aspectual information is crucial in determining temporal interpretations between clauses and within a discourse. Within a narrative context, imperfective aspect (as well as stative lexical aspect) serves a backgrounding function: it doesn't move the action forward

[20] As it happens, the perfective maker is also *le*. It can be distinguished from the terminative *le* by its sentence final (as opposed to immediately post-verbal) position. It has been argued that the two are in fact

but instead sets the stage on which action will take place. The perfective aspect is used to fore-ground action and move the narrative along in time (Berman and Slobin 1996, Wagner 1997, Partee 1984, Kamp and Reyle 1993, Smith 1991).

One temporal connective which is particularly sensitive to grammatical aspect is *when*. *When* has been analyzed as being relatively loose in the ordering relationship it places on its main and subordinate clauses: Hinrichs (1986) has argued that the clauses may be freely ordered, however Smith (1991) and Moens and Steedman (1988) argue that the main clause must happen either during or immediately following the subordinate when-clause (Partee (1984) agrees, I believe, with the Smith/Moens and Steedman position, though she seems to place more weight on the precedence relationship that *when* permits). What has been much less discussed are the factors that lead to different temporal interpretations with *when*[21].

If we take grammatical aspect into consideration, it is possible to be quite precise about the possible temporal orderings of the events in a *when* sentence. Since both clauses may have either the perfective or imperfective grammatical aspect, there are four cases to consider. When both clauses are in the imperfective aspect, the most natural interpretation is where both events overlap completely (52); under this scenario, *when* is equivalent to the connective *while*. When the when-clause is in the imperfective but the main clause is perfective, the when-clause event precedes the main clause event and may overlap with it as well (53). When both the clauses are in the perfective aspect, the when-clause's event precedes the main clause event (54a), although it is possible to get a reading in some cases where the two clause overlap completely (54b). Finally, when the when-clause is perfective

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the same marker, having different effects depending on certain grammatical and contextual factors (Roshenow, 1977, Chan 1979).

[21] Moens 1987 and Moens and Steedman 1988 further argue that there is a non-temporal dimension to the interpretation of *when* clauses, namely that the main clause must be related to the when-clause in some contingent way. Thus, (i) feels odd since it implies the car's breaking down is in some way relevant to the sun's setting (examples from Moens and Steedman 1988).

(i) #When the car broke down, the sun set.

In addition, Moens and Steedman 1988 note (as does Partee 1984 and Hinrichs 1986), that when clauses serve a discourse function of introducing a new temporal interval into the discourse.

but the main clause is imperfective, it is the main clause which precedes the when-clause followed by the two events overlapping (55), contra the analyses noted above[22].

(52) When Gunther was cracking his whip, the lion was roaring.
CRACK = ROAR[23]

(53) When Gunther was cracking his whip, the lion roared.
CRACK < ROAR

(54) a. When Gunther cracked his whip, the lion roared.
CRACK < ROAR

b. When Astaire danced, Rogers danced as well.
DANCE (astaire) = DANCE (rogers)

(55) When Gunther cracked his whip, the lion was roaring.
CRACK > ROAR

The correct analysis of when-clauses appears to have two competing elements: on the one hand, when-clause events do generally precede main clause events but on the other hand, events in the imperfective aspect set the background and both precede and overlap with the other event. In examples (53) and (54a) there is no contradiction between these element but in (52) and (55) there is and it appears that the demands of the imperfective win: in (52) there is no precedence relationship to speak of (only an overlap relation) and in (55), the progressive sentence comes first temporally.

Even temporal connectives which are more rigid about their ordering of events in time, such as *after* and *before*, interact subtly with grammatical aspect. For example, the connective *after* orders events so that the event in the subordinate clause (the after-clause) temporally precedes the event in the main clause. In both sentences (56a) and (56b), the clowns juggle first and are followed by the sword swallower. When the after-clause is in the perfective (56a), the ordering of the events is total: every part of the juggling event precedes every part of the sword swallower's entrance. However, when the after-clause is in the

[22] Actually, Smith (1991) does seem to acknowledge this reading -- the sentences given here are equivalent to her examples on pp. 102-3. However, in the text following the examples she claims that when-clauses always temporally precede main clauses, leaving one confused about her views on the matter.

progressive (56b), it is possible to get an interpretation in which the juggling event continues during the sword swallower's entrance and there is thus overlap of the two events.

(56) a. After the clowns juggled, the sword swallower came on.
b. After the clowns were juggling, the sword swallower came on.

This influence of grammatical aspect on temporal interpretation depends on the grammatical aspect of the clause that describes the temporally initial event. Thus *before* is the opposite of *after* in that it orders the main clause prior to the before-clause. With *before* clauses, the total temporal ordering (equivalent to (56a)) depends on the main clause being in the perfective and the overlapping reading (equivalent to 56b) depends on the main clause being in the imperfective (see 57a and 57b). The effects are somewhat weaker in the *before* case but can be seen given the right context (58). Thus, the ordering properties do not arise from the subordinate clause, per se, but from the grammatical aspect of the temporally prior event.

(57) a. Before the sword swallower came on, the clowns juggled.
b. Before the sword swallower came on, the clowns were juggling.

(58) a. Before the clock struck noon, I ate my lunch.
b. Before the clock struck noon, I was (already) eating my lunch.

2.4. Tense

Tense is a deictic function that situates an event in time relative to a fixed time interval, usually the interval when a sentence is uttered[24]. Let us call this fixed interval the speech time (ST) and the time that the event occurs the event time (ET). The basic tenses (past, present and future) can be defined as the relationship between these two intervals: past tense means that the ET is before the ST (ET < ST), present tense means that ET and ST are

[23] The symbols "<" means temporally precedes, "=" means at the same time and ">" means temporally follows.
[24] The ST does not have to be identified with the moment of utterance and is not, for example, in constructions such as the historical (or narrative) present.

at the same time (ET = ST), and future tense means that ET happens after the ST (ST < ET)[25].

Beginning with Reichenbach (1947) many researchers have argued for the necessity of a third temporal interval, a reference time (RT) (e.g. Hornstein 1990, Klein 1994, Olsen 1994, Smith 1991). In the basic tenses, RT and ET identify the same time interval. The independent contribution of the RT can be seen only in complex tenses like the present perfect and past perfect. In the perfect tenses, ET precedes RT. The separation of the ET and RT points can be seen intuitively in the past perfect construction (59a), where we interpret the event time as happening not only in the past, but past relative to some reference time. This separation of ET and RT can be highlighted with adverbials (59b). In (59b), 5pm identifies the RT and the ghost-seeing (ET) had occurred at some point before then.

(59) a. Anna Eva Fay had seen a ghost.
b. Anna Eva Fay had already seen a ghost by 5pm.

It has frequently been noted that the (Neo-)Reichenbachian tense system is defined along two axes: the ET-ST relationship defines the basic (or absolute) tense relations and the ET-RT relationship defines the complex (or relative) tense relations. However, the nature of the relative tenses owes more to grammatical aspect than it does to tense. This has led some researchers, such as Klein (1994) and Olsen (1994), to treat the ET-RT relationship as providing grammatical aspect information: the RT is used to specify whether the end-point of the event is part of the sentence's temporal assertion; that is, the RT serves as an imperfective/perfective marker. Thus, the present perfect is better analyzed as having a

[25] ET, ST (and RT) are referential elements, referring to time intervals. Like referential elements in the nominal domain, temporal reference can be definite (i), or indefinite (ii) or even be a bound variable (iii). (Examples from Partee 1984).
(i) At 3pm, June 21st, 1960, Mary had a brilliant idea.
(ii) Mary woke up sometime during the night. She turned the light on.
(iii) Whenever Mary telephoned, Sam was asleep.
The referentiality of tense has allowed researchers such as Partee 1984 and Kamp and Reyle 1993 to treat temporal relations in Discourse Representation Theory parallel to the way they treat anaphora phenomena.

tense component (the ET-ST relationship) which corresponds to the present part of the construction and a grammatical aspect component (the RT-ET relationship) which corresponds to the perfect part.

It's not surprising that grammatical aspect would be incorporated into a tense system. There are strong semantic connections between tense and grammatical aspect. Languages that lack morphological encoding of one of these elements can often use the other as a pragmatic cue to the missing element. Thus, in Chinese (which lacks tense), perfective aspect indicates (all other things being equal) that the event is in the past (Smith 1991); in Hebrew (which lacks grammatical aspect; but see Berman 1978) it seems that past tense indicates (all other things being equal) that the predicate is in the perfective aspect (Glinert 1989). Even within a language (like English) which marks both grammatical aspect and tense, there are constraints on how the two can be combined. Most prominently, the present tense is restricted to imperfective aspect for process predicates. When a process predicate appears in a simple present tense form, it has a habitual or generic interpretation (60b). Thus the present tense is a predictor of imperfectivity, though the reverse is not the case.

(60) a. Gunther is cracking his whip (right at this moment)
b. Gunther cracks his whip (generally while training the lions)

Moreover, tense and grammatical aspect markers are often derived from one another historically (Bybee et al. 1994) and the two are often combined in the same morpheme (Dahl, 1985), as with the French imparfait form which codes both past tense and perfective aspect.

Nevertheless, tense and grammatical aspect are distinct semantically and distinguishing them as separate systems allows for a simpler analysis of each. Grammatical aspect reduces essentially to the imperfective-perfective discussed above and tense reduces to the ET-ST relationship.

2.4.1. Multi-Clause Interpretations: Sequence of Tense

The temporal interpretation of tensed sentence complements is dependent on the tense of the matrix sentence although this dependency is not always transparent. Consider the following sentence which exemplifies the famous sequence of tense phenomenon:

(61) Rajesh said that Mona was pregnant.

This sentence has two interpretations which can be paraphrased in the following manners (cf. Hornstein 1987).

(62) a. Rajesh said, "Mona was pregnant"
b. Rajesh said, "Mona is pregnant"

The paraphrase in (62a) corresponds to what is known as the "backward shifted" reading: Mona's pregnancy takes place before Rajesh's saying does. The paraphrase in (62b) corresponds to the "simultaneous" reading: Mona's pregnancy and Rajesh's statement take place at the same time. How can this sequence of tenses, involving a past tense under a past tense, lead to two distinct interpretations?

One explanation argues that there are two possible underlying forms for (61), one in which the embedded sentence is truly in the past tense and one in which the embedded sentences is truly in the present tense. On this account (e.g. Hornstein 1990), English has a morphological rule which transposes embedded present (and future) tenses into a past tense form when they are embedded under a past tense and temporally dependent on it[26]. The temporal dependency manifests itself semantically by evaluating the hidden present tense at the same time as the matrix tense and therefore generating a simultaneous reading. Support for this explanation comes from the fact that in some languages (Greek, Hebrew, and Russian,

[26] It is possible to have an overt present tense embedded under a past matrix tense (i) but in such cases you don't get the simultaneous reading: the present tense here means the present time.

(i) Rajesh said that Mona is pregnant.

for example) the simultaneous reading of (61) is possible only if the embedded tense is overtly a present tense form.

Additional support for this approach comes from the fact that simultaneous interpretations are possible in English only when the embedded event is either stative or in the progressive. Hornstein (1990) argues that this supports the view that the underlying tense with simultaneous readings is a present tense because the same constraint applies to the present tense in isolation: only non-stative events may appear in the present tense not in the progressive and get a non-habitual reading.

As appealing as this view is, it raises the questions, Why should a language like English have a morphological rule whose purpose is essentially obfuscation? and When should such a rule apply in the grammar? Alternative accounts of sequence of tense take the morphology at its face value and ask how the embedded past tense can receive two different past interpretations. The most straightforward of these views (Dowty 1982) argues that the embedded past tense is interpreted independently of the matrix tense and that the different readings arise from pragmatic factors since the semantics merely requires both events to be in the past. Sadly, this account is too simplistic because it predicts that any ordering of the matrix and embedded events is possible, although in fact, one salient ordering, in which the embedded event occurs after the matrix event (but still before the utterance time) is impossible. This is called the "forward shifted" reading and it corresponds to the paraphrase in (63), which of course, is not a viable reading for (61)[27].

(63) Rajesh said on Jan 1, 1994, "Mona will be pregnant (by 1995)"

Enç (1984) solves these problems through a proposed set of syntactic anchoring conditions for tense. I will not go through the syntactic details of her proposal, but in essence, Enç allows embedded tenses to get temporal reference in one of two ways: they may

[27] Forward shifted readings are possible with relative clauses (*Rajesh took in a cat who was later pregnant*) suggesting that there is a syntactic dimension to these interpretations.

be (1) co-indexed with the matrix tense or (2) interpreted relative to the matrix tense. In the first case, when two tenses are co-indexed, they refer to the same time (generating the simultaneous reading); in the second case, the embedded tense is past relative to the matrix tense (generating the backward shifted reading). This approach to sequence of tense will be taken up in the next chapter (§3.7).

2.5. Chapter Summary

This chapter reviewed the basic facts of lexical aspect, grammatical aspect and tense. For lexical aspect, I adopted a taxonomy of lexical aspect properties that distinguishes only between telic and atelic events (parallel to the count-mass distinction in the nominal domain). Grammatical aspect and tense were isolated as distinct systems with grammatical aspect conveying perspective information (akin to the information contained in aspectual verbs) and tense reduced to a simple deictic function of past, present and future.

Chapter 3. Time Machines: A Formal Analysis of Time in Language

This chapter presents a procedural semantic analysis of time in language. Given a sentence and the events happening in the world over a particular stretch of the timeline, it will determine if the sentence is true of the world for that time interval. The bulk of the work in the analysis is accomplished by finite-state automata which provide a means for dynamically evaluating intervals of time. The first section of this chapter will define finite state automata and then motivate their use in creating semantic analyses. The remainder of the chapter will be devoted to the analysis itself.

3.1. Finite State Automata

A finite state automaton is an abstract machine which can compute type-3, or regular, languages (about which, more in a moment). It consists of a finite set of states and transitions among those states. The transitions may be passed depending on the input symbols that come from the alphabet Σ. Finite state automata have no explicit memory and may consider only the current state and the current alphabet symbol in deciding whether to move to a new state. Formally, a finite state automaton consists of a quintuple (Q, S, q_0, d and F) such that:

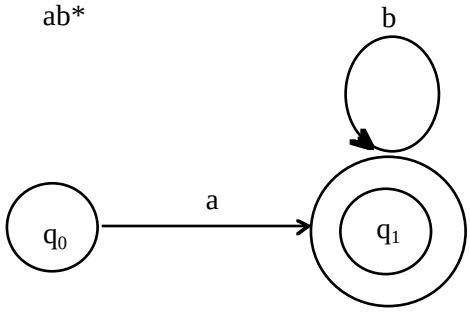
1. Q is a finite set of states
2. S is a finite input alphabet
3. $q_0 \in Q$ is the initial state
4. d is a transition function mapping Q x S to Q
5. $F \subseteq Q$ is a set of final (halting) states

An automaton that reaches a final (halting) accepts the string and one that does not rejects it. Following standard practice I will diagram automata using the following conventions:

1. states are represented by circles
2. transitions between states are indicated by arcs with arrowheads
3. the alphabetic symbol which permits a transition is written along that transition arc
4. final states are represented by circles inside the states

For example, a very simple regular language would be one that consists of a single a followed by an arbitrary number of b's (that is, ab*). An automaton which corresponds to that language is the following:

(64) ab*



The machine begins in the initial state (labeled q_0). The transition arc between the two states may be traversed if the machine reads an a from the input string (as indicated by the "a" label on the arc). This insures that the machine accepts only strings which begin with an a. The second state, q_1, is a halting state (indicated by the circle in its middle) and therefore the machine may accept the string at this point (which is accurate: zero b's is a subset of b*). The looping transition on state q_1 (labeled "b") may be traversed if the next element in the string is a b. Since this transition returns the machine to the same state, the machine may successfully halt after any such transition, that is, after any number of b's -- which is, of course, the desired outcome. If the string should happen to contain at this point another a

(or any other non-b symbol), the machine will reject the string, because it has no legal transitions to make with such symbols.

As noted above, the kinds of strings that can be accepted through finite-state automata are those which can be generated by a regular language. A regular language, in this formal sense, refers to the least complex languages in the Chomsky Heirarchy (type-3 languages) which are those that can be described through the simplest kind of string re-writing rules, namely $A \rightarrow xB$ (where x is a terminal element and A and B are non-terminal elements). The primary constraint regular languages impose is that they restrict the kinds of dependencies elements in the string may have to each other. In particular, they allow an element in the string to depend only on the element immediately preceding it. This fact is captured in the automata by the machines' lack of memory: once a machine is in particular state, it has no way to recall what states came previously.

Despite the simplicity of regular languages and their computing counterpart of finite state automata, a great many things can be described with them, for example, the program that runs a thermostat. A thermostat turns the heater on when the ambient temperature drops below some threshold and turns it off when the temperature rises above that threshold. That is, a thermostat has two states (corresponding to the heater's being on and off). The transition between the off-state and the on-state can be crossed if the thermostat reads a cold temperature from the input. The thermostat remains in the on-state as long as it receives cold input but may cross a transition back into the off-state (which is presumably a halting state) when it receives a warm input. We can define each cycle of the thermostat as the regular string cold*warm (i.e., stay in the on-state as long as it's cold and move to the off-state when it gets warm). Notice that there's no memory needed for this program -- the thermostat doesn't record how many times or when in the past the heater has turned on

There are, however, strings that are more complex than this which are generated by more complex types of languages and which therefore must be computed by more complex

machines than finite state automata. Abstractly, any string which contains non-specific parallelism between elements requires a more complex language. For example, a string containing an arbitrary number of a's followed by exactly the same number of b's ($a^n b^n$) is not a regular language[28]. The machine can't remember how many a's it encountered so it has no way to check if there are an equal number of b's as well. More concretely, a sentence like (65) cannot be generated by a regular language because it requires a variety of interwoven dependencies (indicated by the subscripts).

(65) If$_1$ Barnum$_2$ had either$_3$ known about the hoax$_4$ or$_3$ even suspected the truth, then$_1$ he$_2$ would certainly have found a way to turn it$_4$ to his$_2$ advantage.

A parser of this sentence must be able to link *if* and *then* together, as well as *either* and *or*, *Barnum, he* and *his*, and *hoax* and *it*. A finite state machine cannot represent these links because the parts are separated by an arbitrarily long distance, and lacking any memory, the machine has no way to recall that it had previously seen an *if* when it later encounters a *then*. As might be guessed from this example, natural languages are not equivalent to regular languages. They are in fact two steps up from regular languages on the Chomsky Hierarchy, being (mildly) context sensitive.

3.1.1. Using Automata for Semantics

A regular language may be generated by virtually anything that operates over discrete units. The elements of a language (corresponding to the symbols in the alphabet Σ) could be the presence or absence of electrical impulses in a computer, people competing in a chess tournament, or steps in a logical proof. By identifying some string of elements as belonging to a regular language, we have discovered properties about the ways they can be ordered. The

[28] If we know how many of each we want (i.e., if we know the value of n), say for example, 12, then this becomes a regular language and can be modeled by a finite-state automaton (albeit a long and tedious one). The problem is that the automaton is only good when n = 12 and cannot be generalized to an arbitrary n.

advantage to characterizing problems in this way is that if a problem can be shown to be reducible to a regular language then we know it is computationally tractable: it can be computed by a machine that has a finite number of states and requires no memory (that is, by a finite state automaton). Although we know that natural languages themselves are not regular languages, it is possible to analyze their sub-components as such and that is the approach taken up here in the domain of temporal semantics.

The motivation for using finite state automata in this domain comes from van Bentham (1986), who showed that they could model the semantics of natural language quantifiers. Quantifiers, such as *every*, *no* and *at least three*, evaluate a set of objects in a domain relative to a predicate. To evaluate the quantified sentence *Every woman runs*, the set of women (the NP under quantification) is labaled relative to the predicate *run*: each element in the set of women which also satisfies *run* is labeled with a 1 and each which does not is labeled with a 0. These labels form the string which serves as input to a finite state automaton which is associated with each quantifier. The quantifiers' automata act as computational procedures which determine if the set (reduced now to a string of 0's and 1's corresponding to the quantified NP) meets the requirements of the particular quantifier. For example, the automaton associated with *every* succeeds only if all elements in the string (and hence in the set) are 1's; the machine for *no* succeeds only if all the elements in the string are 0's; and the machine for *at least 3* succeeds only if there are at least three elements in the string which are 1's. In this way, the semantics of quantifiers were reduced to a verification procedure over the objects in a set relative to a predicate.

One of the key advantages to van Bentham's analysis is that it proves the link between definability in first order logic and in regular languages/finite state automata. The starting point for van Bentham's work is found in the set theoretic accounts of quantifier semantics of Barwise and Cooper (1981) and Keenan and Stavi (1986). By proving that his semantic automata analysis is equivalent to their's, van Bentham not only establishes a deep mathematical connection (between predicate logic and the Chomsky Hierarchy) but

effectively doubles the researcher's hypothesis space, as generalizations from one domain can be translated into the other. Further advantages of van Bentham's analysis are that it provides a precise characterization of quantifier semantics and the elements needed to properly evaluate those semantics, and as noted above, it constitutes an existence proof that quantifier semantics are computationally tractable. Part and parcel of these advantages is that the analysis defines limits on the expressability of quantifier semantics. Not everything can be defined in first order logic or computed through a finite state machine, which is all to the good -- not every set-related meaning is coded through quantifiers in language (e.g., the distribution of *only* does not appear to be quite the same as quantifiers like *every* and the semantics of *only* probably cannot be handled by this analysis). Moreover, knowing the expressability limits of a domain is crucial if we want to link the semantics to acquisition in a learnability account (cf. Clark 1998): how a domain is learned depends on the scope of that domain.

Temporal semantics share many properties with the semantics of quantification. In the previous chapter (§2.2.5) I discussed the connection between quantificational properties of nominal elements and events, both at a holistic level and in terms of how the former influences the latter. It therefore seems plausible to extend van Bentham's insight into this domain. The discrete units here are not objects, but time intervals. As in van Bentham's model, intervals will be coded relative to the predicate of the sentence such that time intervals in which a predicate holds will be coded with a "1" and those which it does not with a "0". Thus, to evaluate *Jenny is singing*, time intervals will be coded as "1" if the predicate JENNY SING holds in them and as "0" if it does not. These codes will constitute a string which can be evaluated for aspectual information (such as lexical and grammatical aspect) using finite state automata.

To the extent that the following analysis is a good one for the phenomena of temporal semantics, it accrues the same sort of advantages in the temporal domain as noted previously for quantifier semantics. First, we can be sure that the results from this

algebraically inspired account (see Krifka 1992 and Link 1998 for much of the inspiration) will generalize to analyses using first order logic (cf. much of the work in the Montague semantic tradition). Second, it will provide a precise account of temporal semantics and the elements relevant to their evaluation and will demonstrate that temporal semantics is computationally tractable. Moreover, it will delimit the expressability boundaries of the temporal domain and thereby limit the hypothesis space for learnability. For example, because of its dependence on finite state machines, this analysis would be unable to compute a dependent temporal interleaving. That is, it could not compute the hypothetical connective *gorp*, if *P gorp Q* meant that two individual events P and Q happened in such a way that their sub-intervals alternated with each other, creaing a sequence such as pqpqpqpqpq. Temporal connectives such as *gorp* do not seem to exist in the world's languages which makes it a distinct advantage that the current analysis can't handle them and thereby removes them from the set of hypotheses children must consider in acquiring temporal language.

In addition to these advantages, using finite state automata to model temporal semantics has one additional boon: it brings a dynamic quality to what is clearly a dynamic semantic domain. By its very nature, time is ever-changing and moving forward. Events, which form the basic building blocks of temporal semantics, are dynamic elements which also change and move forward as time does. Finite state automata are also dynamic, evaluating each input element in turn and using it to determine possible state-changes within the machine. Thus, as events in time change (as they must), the machines used to model them also undergo changes (they change internal states). Because change is built into the machines, they are the ideal way to represent the change inherent in events and the flow of time.

3.2. Defining Time

Any treatment of temporal semantics must include an adequate specification of how time is structured. In this analysis, time is treated as a partial order over dense intervals. The treatment here largely follows Allen's (1984) axiomatization of time.

The property of density requires that there is no smallest division of time; any interval of time can be broken down into smaller sub-intervals. Making time dense in this model follows from a strong intuition that time itself is dense, which follows naturally from its being continuous; any time interval we choose, even a very small one like a second, can be broken down into smaller ones like milliseconds or nano-seconds. Density is defined in (66).

(66) Density: For all intervals i and j, i < j, there is a subinterval of i, i' such that i' < j.

The ordering relation used here for time is precedence. This insures that another strong intuition about time is maintained, namely, that time flows in a linear direction forward. The precedence relation is irreflexive (for intervals i and j, if i < j then i≠ j) and transitive (for intervals i, j, and k, if i < j and j < k then i < k). This ordering relation is not total because intervals may overlap with one another, so that it is possible for only part of an interval to precede another one. The precedence relation, called BEFORE, and the OVERLAP relation are defined below. The limiting case on the OVERLAP relation is when two intervals overlap entirely and this is defined below as the EQUAL relation.

(67) BEFORE (i, j) is true if and only if time interval i is before time interval j and they do not overlap in any way. This may be written as i < j.

(68) OVERLAP (i, j) is true if and only if time interval i starts before time interval j and they overlap. This may be written as i ° j.

(69) EQUAL (i, j) is true if and only if time interval i and time interval j are the same interval. This may be written as i = j.

While density and linear ordering have their origins in strong intuitions about the actual nature of time, the choice to treat the basic units of time as intervals (as opposed to

points or instants) requires further comment. The use of intervals is motivated by two considerations. First, there is the intuition that our perception of time is bound up in the things that happen in time and use it up[29]. That is, that time is necessarily counted off by us in chunks -- or intervals -- during which events take place (or in some cases, fail to take place). To the extent that this intuition is valid, it suggests that intervals are a more psychologically plausible unit of time than instants or points are. Second, there are formal reasons to prefer intervals. Any temporal semantics must account in some way for change taking place over time. A system based on instants of time must commit itself to identifying the precise instant when change happens. This leads to a system that is either inconsistent or has truth value gaps. Imagine we want to chart the change from state P to ¬P. The very moment of change must mediate between these two states and must therefore either be both P and ¬P (which is inconsistent) or neither P nor ¬P (which creates a gap in truth values). The solution to this problem used by Allen (1984) (and adopted here) is to use intervals as the basic units of time and to define the primitive relation MEET (defined in 70), which allows for the smooth transition between intervals without inconsistency or gaps.

(70) MEET (i, j) is true iff i < j and there is no time interval between them. In other words, i ends where j starts.

In addition to these strictly temporal operations, we need one further function, the HOLD function, which links time to the rest of the model. The purpose of the HOLD function is to determine what's happening over a time interval. HOLD considers a predicate relative to the world during a time interval; it is defined in (71) below. Much more will be said about mechanism of the HOLD function in section 3.4.

(71) HOLD (p, i) is true if and only if the p is an accurate description of the world during i. HOLD returns 1 when true and 0 when false.

[29] Some philosophers have argued that the entire notion of time depends on things happening (in particular, changing) in it. Cf. van Fraasen (1970) for discussion.

3.3. Overview of the Analysis

It is helpful to think of this analysis as a kind of computer program. There are two inputs to the program: (1) a sentence and (2) the world for some stretch of time. The program outputs either True, if the sentence is an accurate description of the world for that time, or False, if the sentence is not. At the top level of the program, the evaluation procedure has two parts, one for grammatical aspect and the other for tense; both parts must be true in order for the program to return True at the top level.

The tense function identifies when the time interval takes place relative to a fixed point (the time of utterance) and returns True if the sentence bears the right tense. That is, it returns True if the sentence is in the past tense and the time interval is in the past, and so forth. The evaluation of tense will be discussed in section 3.7.

The grammatical aspect function must determine if the event in the sentence has been smeared onto the time interval correctly. To do this, it calls the lexical aspect machine that corresponds to the predicate's event and has its output (True or False) dependent on the output of the lexical aspect machine. For example, the imperfective grammatical aspect function is invoked if imperfective aspect is present in the sentence and the function returns True if the event does not reach an end-point in the time interval. The details of these operations will be spelled out in section 3.6

The lexical aspect automata are the core of the program because they are the machines which actually evaluate the events in the world. Assuming that the interval (i) under evaluation can be partitioned into sub-intervals ($i_1...i_n$), the lexical aspect automata verify whether or not the predicate holds for each sub-interval. Since formally the lexical aspect automata operate only over a string of symbols (and not over the events in the world), these machines must work in tandem with the Hold function which transduces the events in the world into a string of 0's and 1's such that a 1 indicates that the predicate under evaluation holds during a given subinterval and a 0 indicates that it does not. This string

constitutes the formal input to the lexical aspect automata. A lexical aspect machine will return True if upon reaching subinterval i_n, it finds itself in a halting state; it returns False otherwise. The details of the lexical aspect automata are covered in section 3.5.

3.4. The Hold Function

The Hold function evaluates the events happening over a time interval and determines whether those events satisfy the predicate. Formally this is handled by having the Hold function convert its evaluations into a string of 1's and 0's, corresponding to whether the event described by the predicate did or did not happen in a given time interval. It will also be necessary to introduce a special element in the string (termed here "finish") which corresponds to time intervals that contain the causal end-point of an event. But how does the Hold function make this evaluation? How do we decide if a given time interval manifests a particular event, or that event's end-point?

One problem the Hold function faces is identifying the right sized intervals for evaluation: the maximal-minimal interval for a predicate like (72) is a few seconds while the one needed for (73) is perhaps a few thousand years. We don't want the semantics to return False for (73) if there was no continent-shifting over a time interval of only 2 minutes; similarly, we don't want it to return True for (72) if there was no breathing over the course of a year.

(72) Suzy breathed
(73) The continents shifted

Moreover, recall from Chapter 2 (§2.2.1) that this difference in the grain size of evaluation intervals is the only difference between states and atelic processes: any amount of time (no matter how short the duration) is long enough to fully evaluate a state but atelic processes require durations of at least the size of their maximal-minimal interval. Determining the size of the evaluation intervals is therefore a very non-trivial property of the Hold function.

In a similar vein, some events are more tolerant of breaks in their sequence than others. For example, Suzy can still truthfully be *building a house* even if she takes repeated bathroom breaks or even loses financing for a period of months, but as soon as Suzy gets off her bottom she has stopped *sitting*. Generally speaking, telic predicates more readily permit breaks than atelic ones do, presumably because the meaning of a telic predicate depends critically on the end-point whereas an atelic predicate is only about the process itself. This difference hasn't been built into the formal machinery for lexical aspect here however, because the difference does not appear to be principled: *run the 50 meter dash* is telic but it permits no breaks in the sequence while *eating peanuts* is atelic and readily allows for interruptions. The task of determining whether a given interval constitutes an inconsequential or an event-breaking interruption will therefore fall on the shoulders of the Hold function.

Telic predicates pose a particular challenge to the Hold predicate because, by definition, the subintervals of a telic predicate are not themselves complete instances of the event. For example, if, in a given time interval, Otto is seen in the water with arms flailing, the world might be consistent with a swimming event, a drowning event, or a river-crossing event. It is only by knowing how the event ends that we know what kind of event it really is. For these kinds of events, the best the Hold function can offer for pre-coda portions of the event is an evaluation of consistency: is the event consistent with predicate in question?

This question, of how the truth of a predicate can depend on its outcome even when that outcome is beyond the time interval currently being evaluated, has been a concern of the philosophy of language literature (cf. Landman 1992, Dowty 1979). There are two related paradoxes that have been raised, both centering on telic predicates in the imperfective (i.e. the imperfective paradox). The first relates to the likelihood of completion: can we really say that (74) is true when Mary has absolutely no chance of succeeding? The second paradox relates to the problem of incomplete objects: can we really say that (75) is about a house if all that gets built in the interval is a hole in the ground?

(74) Mary was wiping out the Roman army.
(75) Mary was building a house.

I believe that these conundrums are not essentially linguistic in nature. Whether (74) and (75) are true of a given subinterval depends in part on Mary's intentions (is she planning on wiping out the Roman army, or is she planning on committing suicide in glorious fashion?), and in part on our knowledge and beliefs about the situation (perhaps god is on Mary's side and she really will succeed). Moreover, partial objects are a natural consequence of the fact that creating things (and destroying them and changing them) takes time. Knowing that a hole in the ground is a part of a house (its foundation) and not just a hole in the ground depends on what you know about how the hole got there or what someone is planning to use it for. The world grossly underdetermines the possible ways of describing an event and it is through our descriptions that we make commitments about what we know and what we think is intended. The study of the semantics of words like *wipe out* and *house* is separable from the semantics of grammatical elements like tense and grammatical aspect. This chapter has been concerned with analyzing the latter kind of semantics; the former kind has been relegated to the Hold function.

3.5. Lexical Machines

Lexical aspect serves as the link between the meaning of the predicate and the grammatical functions it participates in (at least within the temporal domain). The input to the lexical aspect automata comes from the Hold function. Although Hold may take all sorts of factors into consideration in deciding if a predicate accurately describes an interval, the lexical aspect automata effectively reduces every predicate to its lexical aspect value. Thus, lexical aspect is the only part of the predicate's meaning that interacts semantically with the grammatical aspect and tense functions. Lexical aspect is encoded in this system through

automata: predicates may be associated with one of two lexical automata, corresponding to the telic and atelic aspectual types.

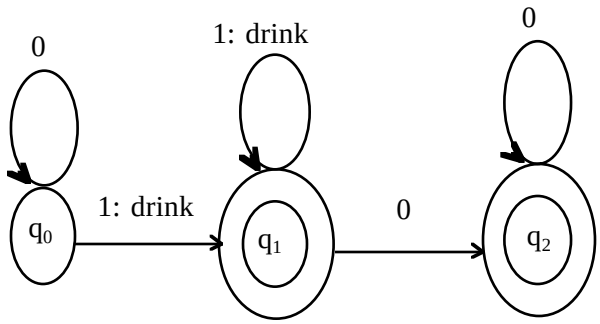
3.5.1. Atelic Machines

Recall that the difference between telic and atelic events is in how they end: telic events have a natural end-point at which they complete; atelic events may successfully stop at any arbitrary time without any change in their entailments. Sentence (76) is atelic (any amount of drinking will satisfy the sentence) and sentence (77) is telic (it completes when the tub is empty).

(76) Juliet drank.
(77) Juliet drank a tub of water.

The lexical automata for sentence (76) is shown in (78).

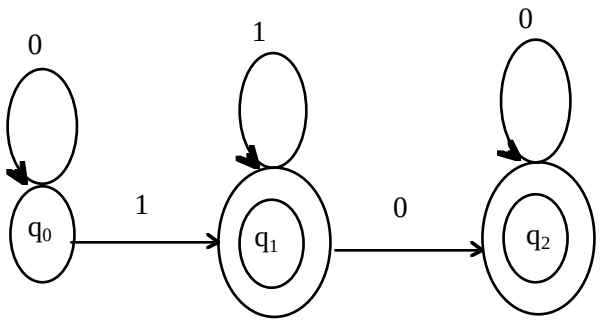
(78) Juliet drank



In this machine, the initial state (q_0) has a loop labeled "0", which is traversed for intervals during which no drinking has taken place. Once some drinking is found to hold over an interval, the transition labeled "1: drink" is traversed and the machine enters state q_1. This state is a halting state, so the machine is accepts the string beginning at this point; that is, a single interval of drinking is sufficient to satisfy this predicate. In practice, that means the

machine commits us to the entailment that if *Juliet began to drink* then *She drank*, which appears to be true. However, as the drinking may continue for an arbitrarily long time, state q_1 also has a loop labeled "1" indicating that the machine will continue to accept more intervals of drinking. State q_1 will be exited by the machine if it receives a "0" (indicating a non-drinking interval) from the input which moves the machine to state q_2. This state accepts only non-drinking intervals (as indicated by the looping "0" transition) but it is a halt state so if the machine reaches it, the string will be accepted. The purpose of state q_2 in this machine is to insure that the atelic event ends once the agent stops the action. We want to capture the intuition that if Juliet walks away from the drinking for some relevantly sized time interval and then returns to drinking, the resumption of drinking constitutes a different drinking event from the first one. Atelic events don't have inherent end-points so the only way we know one has ended is if we encounter a time interval where it's not happening any more. This will be come more important when we consider reference to multiple instances of an event in §3.5.3. The general schema for an atelic event is shown in (79).

(79) atelic schema



The atelic machine is used for both states (*know*, *be red*) and atelic process (*drink*, *think*) in keeping with the classification offered in §2.2.5. which grouped the two together on the basis of their shared homogenous structure[30]. This property of homogeneity (i.e. that each sub-interval of the event is itself an instance of the event) is captured in the atelic machine by

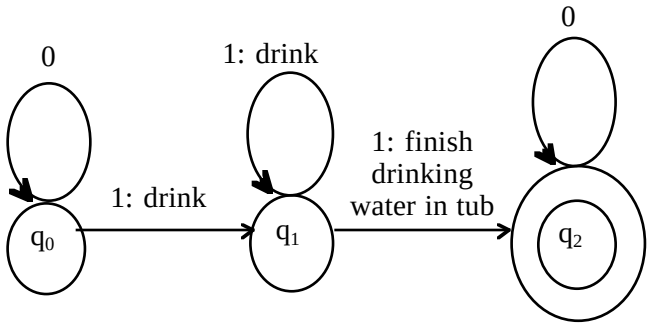
[30] The difference between states and atelic processes is one of grain size, which, as noted previousl is handled by the Hold function.

the fact that the machine makes only a two-way distinction over intervals: it operates over intervals where the event happens ("1") and intervals where it does not ("0"). This leads naturally to the corresponding fact that any number of intervals where the event occurs is sufficient to satisfy the machine since all the sub-intervals are equivalent.

3.5.2. Telic Machines

The analysis of telic predicates must incorporate the fact that telic events are non-homogeneous and have a natural end-point. The machine for sentence (77) is shown in (80).

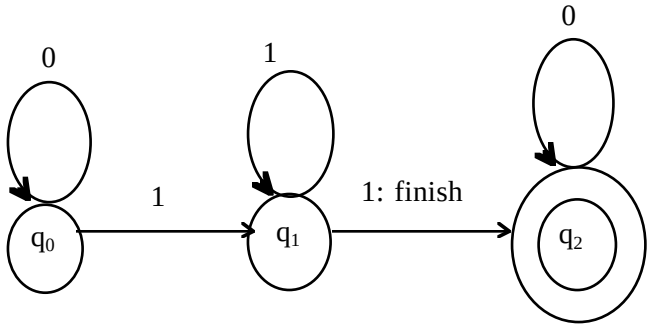
(80) Juliet drank a tub of water



The first parts of the telic machine are very similar to the atelic machine. The initial state (q_0) has a looping "0" transition for non-drinking intervals, then, once drinking begins, the "1" transition is crossed into state q_1 where the drinking may continue for an arbitrarily long time via the looping "1" transition. Unlike the atelic case, this machine cannot halt in this state because *drink a tub of water* specifies its completion point (when the tub is empty) and the machine will not accept the input string unless it provides such a point. The transition labeled "finish" must be crossed to reach state q_2 which is the telic machine's only halting state. The "finish" transition requires the input to provide an interval corresponding to the completion of the event. Such an interval is causally connected to the previous intervals where the event was occurring, but it is qualitatively different. That is, the tub's being empty

is the result of Juliet's prior drinking and is the specified end-point of that drinking event, but it is not itself an event of drinking. Once the halt state has been reached, the event does not continue, as indicated by the fact that only non-instances of the event ("0"'s) are accepted in this state. The basic schema for a telic predicate is shown in (81).

(81) Telic Schema



The distinction between the "1" transition and the "finish" transition captures the non-homogeneous property of telicity: not all the non-zero intervals are the same and telicity requires both process ("1") intervals and result ("finish") intervals to succeed. This distinction also accounts for why telic predicates have two readings with *almost* (83) while atelic predicates have only one (82) (examples are repeated from Chapter 2).

(82) The clown almost ran after the tiger
... but she thought better of it and didn't start

(83) Wallenda almost crossed the high-wire walking on her hands
... but decided it was too dangerous and didn't start
... but fell half way across

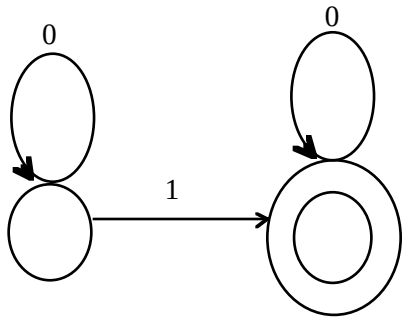
The adverb *almost* targets non-zero transitions and indicates the failure to find an interval which satisfies them. The atelic machine has only one such transition and so if no "1" intervals are found, the event does not occur. The telic machine, however, has two non-zero transitions: if no "1" intervals are found the event, as with the atelic case, does not occur; if no "finish" intervals are found, the event begins, but does not complete.

3.5.2.1. Non-Duratives

Non-durative predicates (*reach the edge*, *crack the whip*) are classed here as telic events (cf. the discussion in §2.2.5) and therefore are analyzed with the telic machines. This is somewhat problematic as the telic machine has no way to capture the atomic quality of these events. In order for a telic machine to reach its halting state, it must traverse at least two transitions (and therefore evaluate two sub-intervals), one from the initial state to state q_1 and then the "finish" transition to the halt state. In principle, this is not a problem because we are treating time as dense so even an intuitively atomic event can be divided up into subintervals. In practice, however, an appeal to density is not very satisfying.

One possible solution to the problem would be to define a third lexical aspect machine which satisfied the properties of atomicity, such as the machine shown in (84).

(84) Atomic Machine



The viability of atomic machines, however, is not going to be pursued here. The primary advantage of collapsing the atomic predicates with the other telic predicates is that it provides an elegant analysis for how the non-durative predicates can be interpreted (when in the imperfective aspect) as referring to their preparatory state. For example, *Jackie was winning the race* refers to the running that leads up to the actual winning and *Suzy was burping* can refer to the process of burping under the right circumstances (such as a slow-motion video of the burp). In the telic machine's schema, state q_1 has a looping transition which is optionally traversed; the optionality allows the transition to be available when needed (as when the predicate is in the progressive and the time intervals refer to preparatory

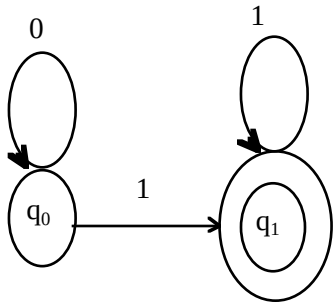
stages) but also allows the machine to move straight to the completion state after the inception of the event. The optional loop represents something of our implicit knowledge about how events work: events in the world don't just complete (races are never won without the race transpiring beforehand) and although some sentences don't highlight those preparatory stages, they are still there, waiting to be called up by the right linguistic device.

3.5.2.2. Composing Lexical Aspect

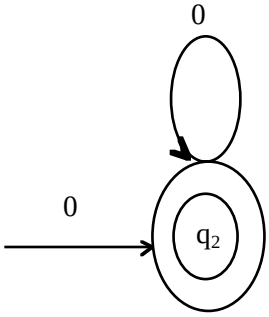
Conceptually, these lexical aspect machines can be decomposed into two parts: the first part, the "pre-coda" consists of the first two states and the transitions between them, and the second part, the "coda" consists of the transition leading to the last state. The pre-coda for the telic and atelic machines are very similar; they differ only in that the q_1 state of the atelic pre-coda (86) is also a halt state while it is not for the telic pre-coda (88). The codas for the telic and atelic machines differ dramatically, reflecting the very different ways that these events end. The coda for the atelic machine (87) is entered through a "0" transition that indicates the event is no longer happening. The telic coda (89) is entered through a "finish" transition that indicates the result of the event has happened. The composition of a complete machine is accomplished through a simple concatenation rule (85). The application of the rule to the pieces of the machines is shown below.

(85) COMPOSITION RULE: Identify the last state of the pre-coda as the source state for the coda's input transition.

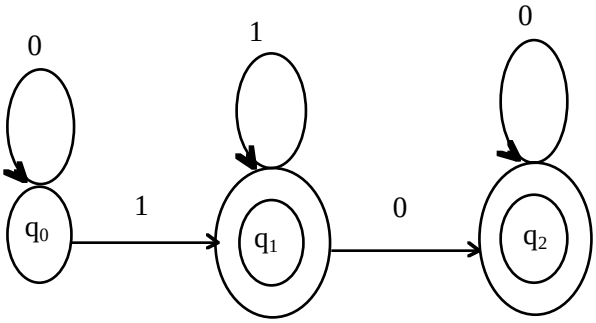
(86) Atelic pre-coda



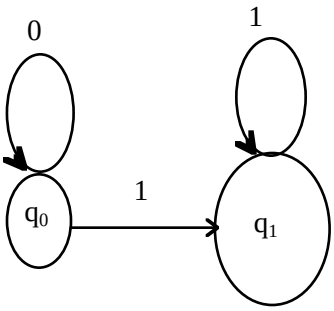
(87) Atelic coda



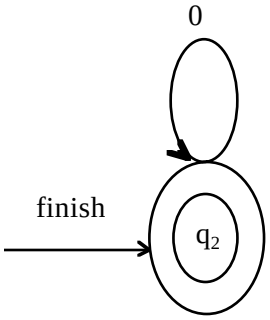
(79) Atelic Schema (as seen before)



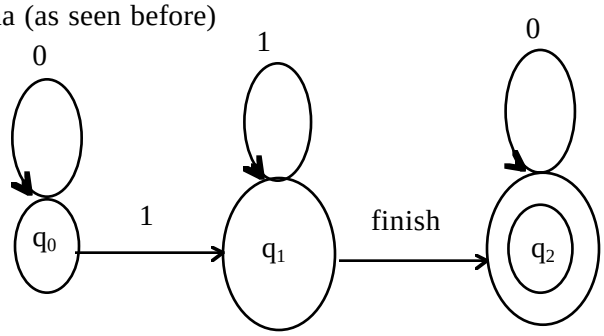
(88) Telic pre-coda



(89) Telic coda



(81) Telic Schema (as seen before)



The compositionality of the lexical aspect machines parallels the linguistic composition of lexical aspect discussed in Chapter 2. Telic interpretations are (usually) dependent on having a linguistic specification of their end-point (a cardinally quantified direct object or a directional PP) and we can think of these linguistic elements as contributing the telic coda to the semantic analysis. The atelic coda indicates the absence of the event and this does not require particular lexical specification.

3.5.3. Composing Multiple Events

Any sentence which contains a cardinal quantifier may receive a multiple event interpretation. The most basic case of this is when there is an adjunct that explicitly targets the event as a whole, as in (90).

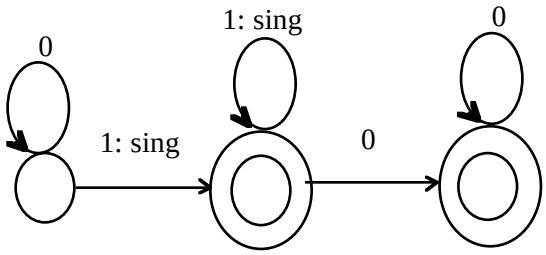
(90) Jenny Lind sang 3 times yesterday

In order to account for such multiple events, the analysis needs a means of connecting separate instances of events over a time period. To wit, the Serial Concatenation rule which links the events one after another in a serial fashion. The rule is stated in (91) and illustrated in (92).

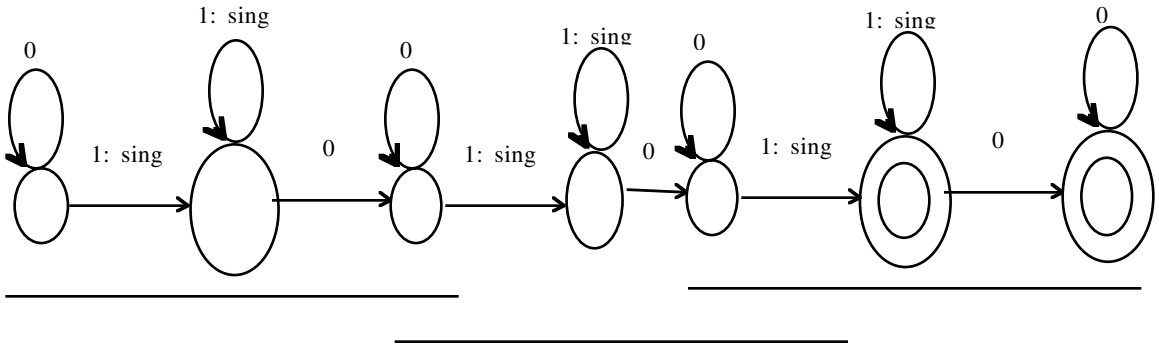
(91) Serial Concatenation rule
- (i) compose a machine for each event.
- (ii) delete the halting state(s) from the first machine from the set of halting states
- (iii) identify the initial state of the second machine with the last state of the first machine (where the last state is defined as a state which has no transitions leading to another state)
- (iv) treat this new concatenated machine as the first machine and repeat steps ii-iv as necessary.

(92) Lind sang 3 times

(a single singing event)



(Three events of singing, serially concatenated: note that each individual event is underlined)

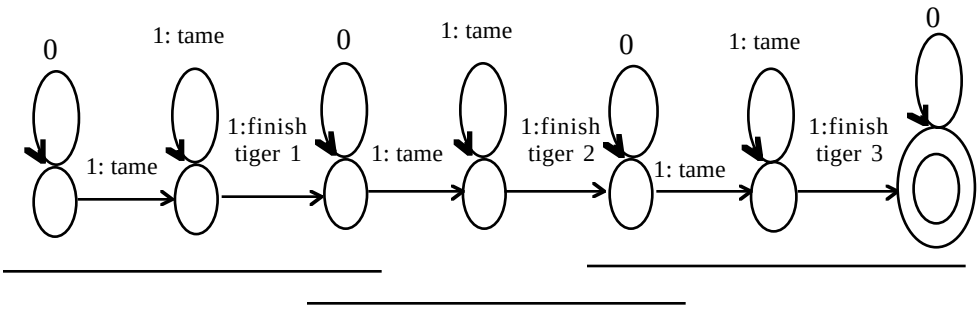


The interpretation here is that there was one instance of singing followed by another instance of singing followed by a third. That is, the event of singing happens 3 times, as specified in the sentence. We can see from this example the importance of the coda for the atelic machine: it serves to create the mandatory pauses of non-singing between the singing events which are crucial to our recognition of distinct events. Suppose that the singing event of interest here is when Lind hits high C, something she can do for about 30 seconds at a time. We want to be able to distinguish between three events lasting 30 seconds each during which Lind hits the note (a normal set of events for her) and one event lasting 90 seconds during which Lind hits the note (an unusual event for her). What separates these two cases are the sub-intervals of non-singing (that is, the codas) that intervene after 30 seconds in the first, but not the second case.

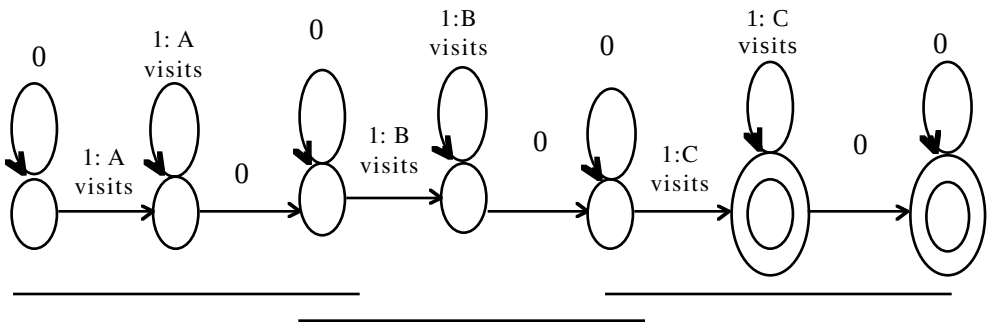
Multiple interpretations like this are possible given a cardinal quantifier in any part of the sentence -- the subject, object, prepositional phrase or adjunct. Thus we apply the serial concatenation rule for the sentences (93) and (94), where the number of events to be concatenated is determined by the cardinal element. The machines for these two sentences are shown in (95) and (96). Notice that since (93) contains a telic predicate, the machines that undergo the concatenation rule are telic (note the finish transitions) while the atelic event in (94) concatenates three atelic machines.

(93) Gunther tamed three tigers
(94) Three Ringlings visited a vacation spot in Florida

(95)



(96)



In these cases of serial interpretation, the cardinal element takes scope over the event composition and dictates the number of events (and hence, machines) to build. Thus (95) interprets (93) as meaning Gunther tamed one tiger and then another and then a third and

(96) interprets (94) as meaning one brother visited Florida, and then a second brother visited and then a third.

However, the presence of multiple elements in an event doesn't always lead to lead to a multiple event interpretation. For example, sentence (93) could mean that Gunther tamed all three tigers at once and sentence (94) could mean that the Ringling brothers visited Florida all together (adverbials like *N times* refer explicitly to events and so always lead to the serial interpretation). To account for these unified interpretations we need to consider more closely the relationship of the pre-coda to the coda. In the basic composition of a machine, there is only one pre-coda and one coda so the options for concatenation of these parts are limited to one: the coda attaches to the pre-coda. The serial concatenation operated over machines that had already composed the coda to the pre-coda, but in the unified interpretation we want to be able to combine several codas with the same pre-coda. That is, we want the several instances of a result (i.e., several tame tigers) to be the product of the same process.

What is needed, therefore, is an algebra for combining codas and pre-codas that will account for the range of possible interpretations including the unified interpretation. Pieces of this algebra have already been used in the serial concatenation rule and the basic composition rule proposed before. The complete algebra for lexical aspect combination is shown below.

(97) Combination Algebra

(i) Concatenating a coda to a pre-coda (cf. 85):
Identify the last state of the pre-coda as the source state for the coda's input transition
(ii) Concatenating a pre-coda to a coda (cf. 91):
Delete the halt state of the coda and any other halt states prior to the coda from the set of halting states and identify the initial state of the pre-coda with the coda's state.
(iii) Concatenating a pre-coda to a pre-coda:
Identify all states and transitions of two pre-codas (i.e., reduce the two to a single pre-coda)
(iv) Concatenating two Atelic codas:
Identify all states and transitions of the codas (i.e., reduce the two to a single coda)

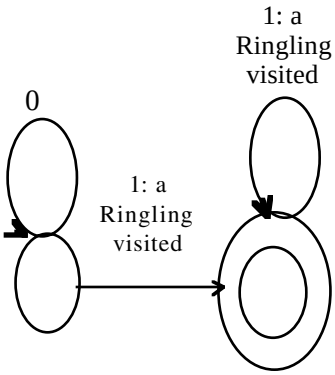
(v) Concatenating two Telic codas:
Identify the halt state of the first coda as the source state for the second coda's input transition and then delete it from the set of halt states.
(vi) Global Constraint
The pre-coda of an event must precede the coda for that event.

The number of pre-codas and codas are always the same and they are determined by the cardinality of the cardinal quantifier in the sentence (or if there is no such quantifier, there is one of each). Statement (i) of the algebra is simply a re-statement of the basic rule for machine composition and was previously illustrated (for n = 1) in examples (86) through (89). Statement (ii) is crucially taken advantage of in the serial concatenation rule proposed earlier. Because serial concatenation operates over already composed machines, its combination method was to link the end of one machine onto the beginning of another and examples of this sort of combination were given in (92) to (96). Statement (iii) is the means for getting unified interpretations. The algebra permits all of the pre-codas to precede all of the codas; that is, for all of the process parts of the events to precede any of the results. When multiple processes (i.e., pre-codas) are concatenated, however, they are functionally indistinguishable from only a single process (i.e., pre-coda). Which is to say that n pre-codas concatenated together accept exactly the same strings that 1 pre-coda does and it is for this reason that statement (iii) identifies them all as a single pre-coda. A similar logic is used for the identification process in statement (iv): atelic codas consist of non-instances of the event and a sequence of machines accepting only non-instances are equivalent to a single such machine. There is no identification of multiple telic codas in statement (v) because different result states can (and must) be distinguished. That is, if Gunther tames three lions, there should be three, distinct tame lions at the end of the process. Finally, the statement in (vi) insures that the basics of cause and effect are maintained in the system.

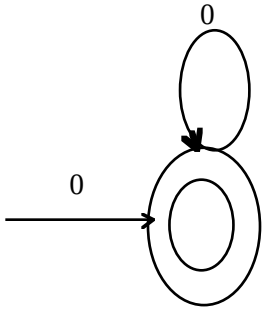
To see how the algebra works, let's begin by creating the completely unified interpretation for examples (93) and (94), whose serial interpretations were demonstrated above. On its unified interpretation, sentence (93) means that the three Ringling brothers

visited all together. Since *visit* is an atelic predicate, we begin with three atelic pre-codas (as in 98) and three atelic codas (as in 99). Because the processes of visiting for each brother all happen before the end of any of the events, we combine the machine pieces so that all the pre-codas are concatenated together followed by all the coda pieces. Then, by statement (iii), the pre-codas are all identified with each other leaving only a single pre-coda and by statement (iv), the atelic codas do likewise. This leaves us with the machine in (100). Notice that this machine is identical to the machine for an atelic predicate describing a single event.

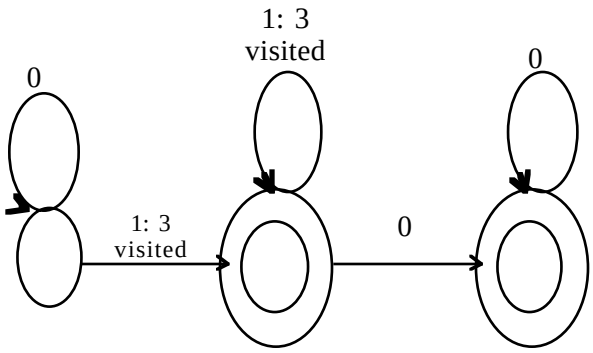
(98) Pre-coda for visit (3 needed)



(99) Coda for visit (3 needed)



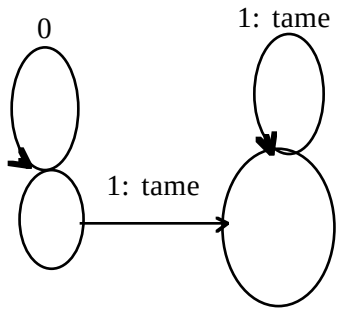
(100) Machine for unified interpretation of 3 Ringlings visited



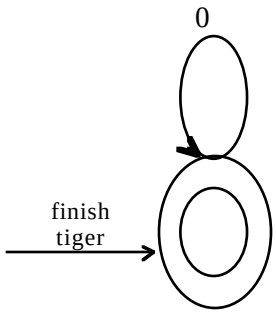
The unified interpretation of (94) means that Gunther tamed all three tigers as part of the same training sessions. Because of the cardinal quantifier *three*, we begin with three pre-codas

and three codas (shown in 101 and 102). The completely unified interpretation means that the process of training all the tigers preceded the actual taming of any one of them, so again, this means that all the pre-codas precede all the codas. Again, by statement (iii), the concatenation of multiple pre-codas causes them to unify into a single pre-coda. Because this predicate is telic, however, there is not a similar collapsing of the codas and the identity of each tame tiger result is preserved in the machine. The result of the combination is shown in (103).

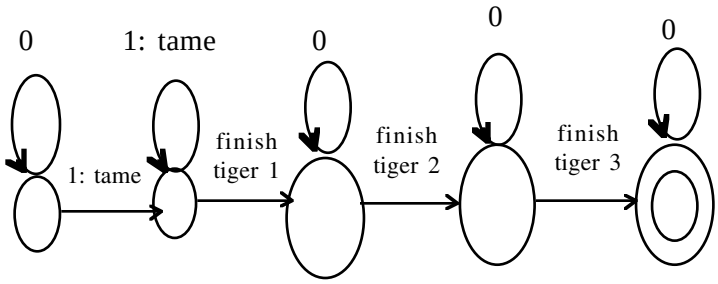
(101) Pre-coda for tame (3 needed)



(102) Coda for tame (3 needed)



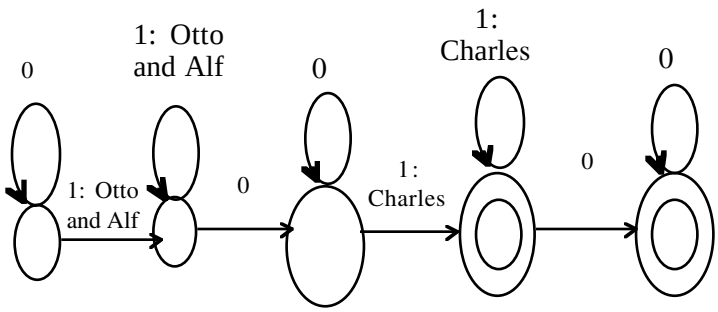
(103) Machine for unified taming interpretation



So far we have considered only the most extreme cases. In the examples just shown, the pre-codas and codas were completely grouped together by kind (with all of the pre-codas preceding all of the codas) and in the serial case, the pre-codas and codas were completely interleaved (regularly alternating pre-codas and codas). The algebra itself, however, imposes no constraints on how the interleaving of the two pieces is to take place (aside from the

global constraint in (vi) to maintain basic causality) and thus it allows for intermediate readings. For example, *Three Ringling Brothers visited Florida* could mean that Otto and Alf went down together and then Charles took a trip on his own. Such an interpretation would involve combining the pre-codas for Otto and Alf's visit followed by the codas for their visit followed by the pre-coda and coda for Charles' visit[31]. The machine that represents this interpretation is shown in (104).

(104) Otto and Alf Ringling visit then Charles visits



Finally, we turn to a more complicated case, when there are more than one cardinally quantified element, as in sentence (105).

(105) Four men lifted three pianos

The combination algebra defined here won't work with sentences of this type because we can't determine how many pre-codas and codas to combine. On some interpretations of this sentence, the pianos are subordinate to the men (so there are three pianos for each man) and on others, the men are subordinate to the pianos (so there are four men for each piano). Worse yet, intermediate combinations of these readings are also possible (as when three men lift one piano and one man lifts two pianos) which distribute men and pianos with respect to

[31] An additional interpretation of this sentence is possible: Otto, Alf and Charles might engage in three separate visits that all happen at the same time. This interpretation will have to be treated as containing an

each other in a variety of ways. The quantifiers in this sentence are dependent on each other and so can't be treated by the finite-state operations which define the current analysis. In fact, Van Bentham (1989) has analyzed these "polyadic" quantifier combinations as being non-first order as well as non-compositional so it really comes as no surprise that the first-order analysis here cannot handle them. An analysis of these examples (as well as the integration of quantifier semantics into these temporal semantics more generally) will have to wait for future work.

3.5.3.1. Unquantified Event Iteration

The previous examples have all concerned cases where the actual number of events to be combined was provided through the cardinality of quantifiers in the sentence. However, it is possible to get multiple event interpretations without such quantifiers; that is, it is possible for events to iterate more generally. As was discussed in Chapter 2 (§2.2.5), all telic events are subject to iteration if the time interval of evaluation is sufficiently large relative to the time it takes for the event to happen, although no events are required to iterate. The formal analysis of iteration is identical to that of the analysis for multiple event combination presented above. Typically, iteration implies serial concatenation. For example, the sentence *Gunther cracked his whip for an hour* seems to mean only that one complete event of whip-cracking was followed by another complete whip-cracking event and so on. However, it appears that the full range of multiple event readings are possible in some unspecified iteration cases. Thus, *Amy wrote her name for hours* could mean that she wrote a long series of "A"'s followed by a series "m"'s followed by a series of "y"'s and such a reading would require the pre-codas of the event to be concatenated together as a unit followed by the codas as a unit. For this reason, the entire combination algebra is left as an

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implicit *while* which is the means in this analysis for allowing multiple events to happen independently at

option for iteration cases and this analysis makes no formal distinction between the cardinally quantified event combination process and the unquantified iteration process.

3.6. Modifying Machines: Grammatical Aspect

Grammatical aspect provides information about how an event progresses in time. Since the lexical aspect machines are the representation of events in this analysis, grammatical aspect should tell us something about how these machines progress through a time interval. Abstractly, we can think of grammatical aspect as a Universal Turing machine which runs a lexical aspect machine over a given input string and whose output depends on the output of the lexical machine. In practice this means that grammatical aspects can be analyzed as sets of functions which operate over the lexical aspect machines, in some cases leaving them unchanged, in other cases modifying them and, particularly in the case of the aspectual verbs, combining them.

3.6.1. Perfective Aspect

Perfective aspect is the simplest grammatical aspect function because it leaves the lexical aspect machines alone and simply runs them as they are. When the lexical aspect machine accepts the input string (i.e., successfully reaches a halting state), the perfective function returns True and when the lexical machine rejects the input string, it returns False. This function is stated formally in (106).

(106) For lexical automaton A and time interval *i*
PERFECTIVE (A, *i*) = {true iff A(*i*) halts; false otherwise}

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the same time (cf. §3.8).

For the telic machines, which may halt only in their coda (defined by the event's completion), perfective grammatical aspect will require these machines to reach that coda, thus generating the entailment of completion found with telic predicates in the perfective. Atelic machines, on the other hand, may halt either in their coda or in their pre-coda, so perfective aspect will not force these events to end (i.e., be bounded by a period of non-happening).

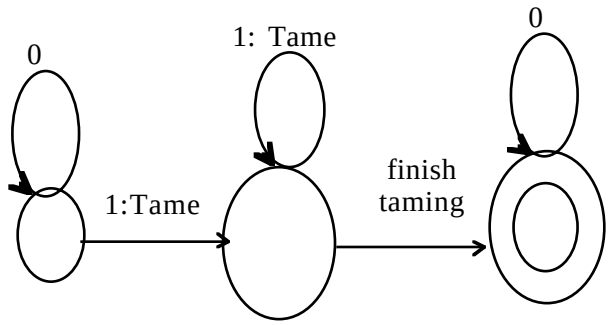
3.6.2. Imperfective Aspect

Imperfective aspect specifies that an event is ongoing and has not reached its completion point in the interval specified. The imperfective function, therefore, must modify the lexical aspect machine it runs so that the success of that machine depends on its non-completion. This is accomplished by redefining the halt states so that a state (s_n) is in the set of halt states (F) if and only if the following two conditions are met: (1) the state is not an initial state (q_0) and (2) there is some other (distinct) state in the machine (s_m) which can be reached from s_n through a legal transition (δ is the transition function) given the right input element (Σ is the input alphabet). The truth of the imperfective function depends on the acceptance of the string by this revised lexical aspect machine. The formal statement of the imperfective function is in (107).

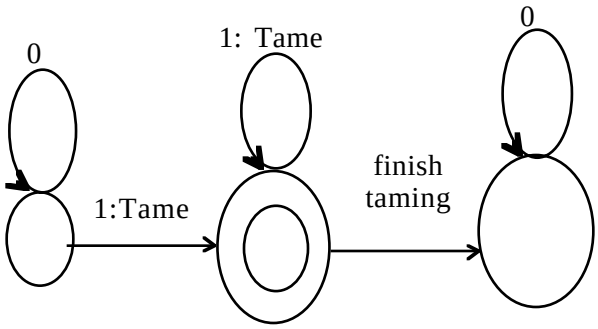
(107) For lexical automaton A and time interval *i*
IMPERFECTIVE (A, *i*) = {true iff A'(*i*) halts; false otherwise}
where A' is the lexical automaton A subject to the following modification:
$s_n \in F'$ iff $s_n \neq q_0$ AND $\exists s_m$, $s_n \neq s_m$, and for some $x \in \Sigma$: $\delta (s_n, x) = s_m$.

For example, the imperfective function will convert a telic machine like the one in (108), the analysis for *Gunther tamed a tiger*, into the machine in (109), which is therefore the machine for *Gunther was taming a tiger*.

(108) Gunther tamed a tiger



(109) Gunther was taming a tiger.

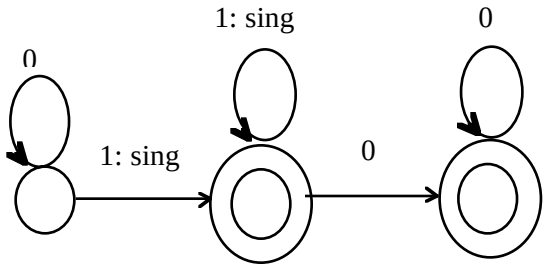


The difference between the two machines is that (108) succeeds only when the tiger is actually tamed while (109) will fail if the machine crosses the completion (finish) transition. This covers, therefore, half of the entailments of the imperfective paradox: when a telic predicate is placed in the imperfective, it loses its entailment of completion. It may appear from this definition of the imperfective that it actually entails the lack of completion of a telic event (which is incorrect) but this is not strictly true once we look at the machine in context. The imperfective function (and by extension, the lexical aspect machine) is true with respect to a given interval *i* and, as suspected, within that interval *i* the imperfective function does entail lack of completion of the event. However, time is a continuous function and whatever the interval *i* that is evaluated by the machine here, there is an interval *i* + 1 which comes after the evaluation period has ended. The imperfective function has nothing whatsoever to say about what happens to the machine (or by implication, the event) after

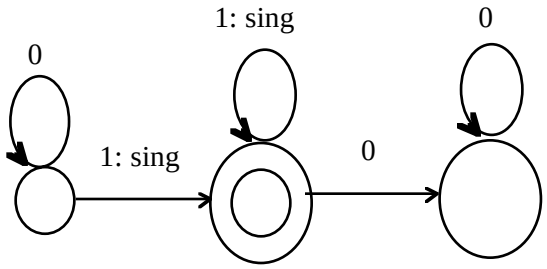
the evaluation interval has ended, leaving plenty of opportunity for the coda transition to be crossed at a later time[32].

To account for the other half of the imperfective paradox, we must look at the effect of the imperfective function on an atelic machine. For example, (110) shows the machine for the atelic predicate *Jenny sang* and (111) shows the machine for the imperfective, *Jenny was singing*.

(110) Jenny sang.



(111) Jenny was singing.



The other part of the imperfective paradox states that if an atelic predicate in the imperfective is true (*Jenny was singing*) then the perfective version of that sentence will also be true (*Jenny sang*). These entailments are maintained in this analysis by virtue of the fact that q_1 (the middle state) is a halt state for atelic machines generally (and therefore for these machines in the perfective aspect) and also meets the imperfective's criteria for being a halt

[32] Thus, we associate Smith (1991)'s spot-light of attention with the particular time interval under evaluation. This solution has much in common with the one proposed by Klein (1994).

state (namely, having an out-going transition). Thus any atelic machine which succeeds under imperfective aspect will also be able to succeed under perfective aspect.

In essence, the imperfective function allows the machine to halt at any point after the event has begun and before the very last state of the machine has been reached. When the imperfective is applied to multiple event interpretations, therefore, it will allow sub-events to reach completion, so long as all the event as a whole does not. That is, *Gunther was taming 3 tigers* will be accepted if Gunther completes the taming of tigers one and two so long as he does not complete the taming of the third tiger. With iterated predicates, such as *Amy was writing her name for hours* or *Suzy was burping*, the imperfective requires that (at least) the final event in the iteration not be completed. This is slightly counter-intuitive for the serial iteration cases (e.g., *Suzy was burping*) because it requires the interval to end with Suzy in mid-burp: if she completes that last burp, the machine moves to a q_2 state which is not a halting state for the imperfective. This consequence, however, seems like a small price to pay.

3.6.3. Aspectual Verbs and Resultatives

At the semantic level, aspectual verbs and resultatives are on a par with imperfective and perfective grammatical aspect: they provide information about how an event proceeds by simulating a modified lexical aspect machine. The aspectual verbs *begin* and *finish* are quite similar to imperfective and perfective aspect in that the modifications they make involve the restrictive specification of halt states.

In fact, the aspectual verb *begin* defines exactly the same function as the imperfective, stated here formally in (112).

(112) For lexical automaton A and time interval *i*
BEGIN (A, *i*) = {true iff A'(*i*) halts; false otherwise}
where A' is the lexical automaton A subject to the following modification:
$s_n \in F'$ iff $s_n \neq q_0$ AND $\exists s_m$, $s_n \neq s_m$, and for some $x \in \Sigma$: $\delta (s_n, x) = s_m$.

The definition predicts two entailments for sentences with *begin* (113). First, it entails that the event begin (because q_0 is not a halt state) which is clearly true; and second, it entails that the event not complete within the time interval under evaluation. This entailment also appears to be true as (113), like imperfective sentences, can be felicitously combined with the continuation, *but they never reached the other side*.

(113) The Wallendas began to cross the high-wire

The aspectual verb *finish* is similar to perfective aspect but is somewhat more restrictive. In particular, *finish* entails that the event has ended. For telic events, it entails completion (as with the perfective aspect) and with atelic events it entails the event actually cease. That is, sentence (114) means not only that the clown was successfully engaged in juggling (i.e., a juggling event was in evidence) but that the juggling event ended, as determined by some interval of non-juggling which followed it.

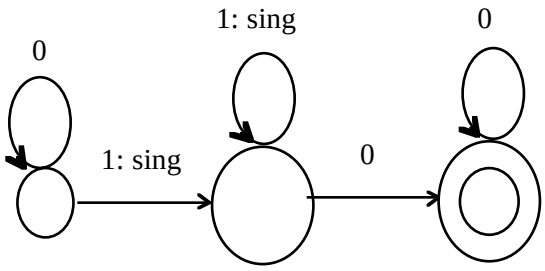
(114) The clown finished juggling.

Finish is a function which is satisfied only if the lexical machine it applies to reaches the very last state in the machine (i.e., the last coda state in the machine from which there are no outgoing transitions to a new state). This is defined formally in (115).

(115) For lexical automaton A and time interval *i*
FINISH (A, *i*) = {true iff A'(*i*) halts; false otherwise}
where A' is the lexical automaton A subject to the following modification:
$s_n \in F'$ iff $\neg\exists s_m$, $s_n \neq s_m$, and for some $x \in \Sigma$: $\delta (s_n, x) = s_m$.

Since the modification imposed by *finish* on a telic machine is vacuous (the halt state picked out by finish is already the standard halt state for a telic machine) it will not be diagrammed here. The machine generated by *Jenny Lind finished singing* is shown in (116).

(116) Jenny Lind finished singing.



Notice that the effect of *finish* is essentially to turn an atelic machine into a telic machine, where the telic "finish" transition is now represented by a "0" transition corresponding to the fact that completion for an atelic event is simply the absence of that event.

Resultative verbs and constructions are somewhat more complicated because they involve the combination of machines, and not simply the alteration of an existing machine. Resultatives provide information about two stages of an event: first they identify a process that leads to a result and then they focus on the result state that arises from this event. In English, the perfect construction has resultative force (117) as does the aptly named resultative construction (118).

(117) The Wallendas have crossed the high-wire.
(118) Suzy hammered the nail flat.

Resultatives are analyzed here with an atelic machine (encoding the result state) melded onto the end of another machine. The term "melded" is used instead of simply "combined" to reflect the fact that parts of each machine are eliminated in putting them together. In particular, the halt states of the basic event's machine and the initial state of the result machine are removed and the transition function (δ) is re-defined so that the last remaining

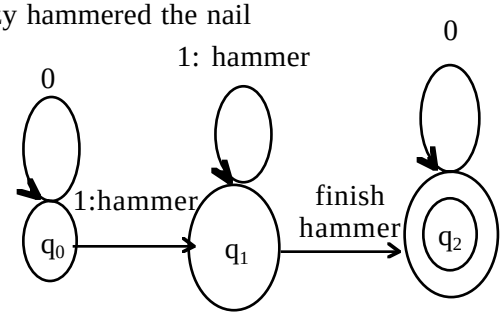
state of the first event machine leads to q_1 of the atelic machine. The resultative function is described formally in (119); the melding process it makes use of is defined in (120).

(119) For lexical automaton M and time interval *i*
RESULTATIVE (M, *i*) = {true iff M(*i*) halts; false otherwise}
where M is the output of MELD (A, B) and B is an atelic automaton

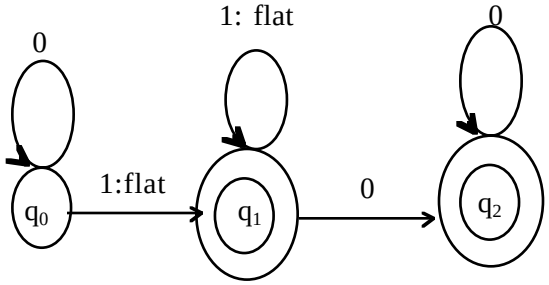
(120) MELD (A, B)
(i) In automata A, if $s \in F$, delete s
(ii) In automata B, if $s = q_0$, delete s
(iii) Redefine δ such that for some $x \in \Sigma$, $\delta(s_i, x) = s_j$, where within A, $\neg\exists s_n, {}_{si} \neq s_n$ and for some $x \in \Sigma$: $\delta(s_i, x) = s_n$ and within B, and $s_j = q_1$

The effects of the resultative function (and meld function) are illustrated below for the sentence *Suzy hammered the nail flat*.

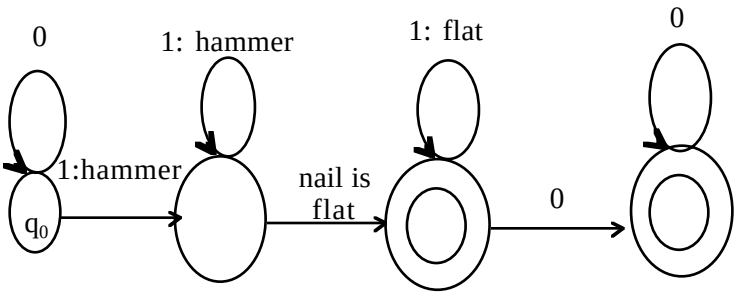
(121) Suzy hammered the nail



(122) the nail is flat



(123) Suzy hammered the nail flat



There has been a small bit of fudging in creating this resultative machine because there has been no mechanism introduced to insure that the result state that gets added is causally related to the event it melds with. In principle, this resultative rule allows us to combine an event of walking the dog with the result of a built house. This seems counter-intuitive but it may not be impossible: if Suzy is a witch and she works her magic by walking the dog, then a house might not be such an unreasonable result of such an action (cf. also Link 1998). To the extent that this is a problem that should be handled in the semantics, we relegate it to the Hold function and our extra-linguistic knowledge.

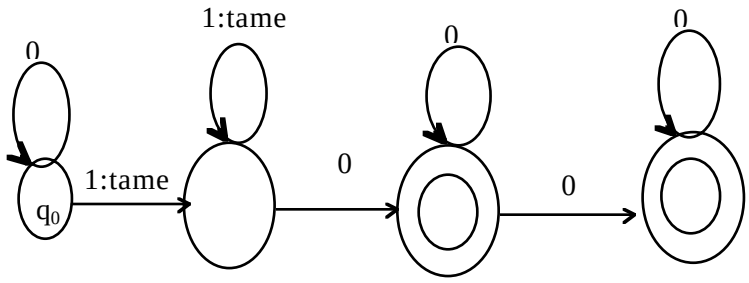
From this analysis we can see how to account for more complex resultative markers such as Mandarin *guo*. Recall that Mandarin *guo* indicates that a result state has ended and no longer obtains. It is accounted for on this analysis by the application of the finish function (which requires the halt state to be in the coda) applied on top of a resultative melding. Moreover, we can speculate as to why perfective markers often take on an inceptive meaning when applied to states[33].

We can analyze the aspectual verb *stop* as a special version of the resultative function. The result that gets melded onto an event in the stop case is the absence of the

[33] In English, when *finish* is applied to a resultative it seems to be restricted to the base event. That is, Suzy finished hammering the metal flat means that the hammering was finished, not that state (as in the Mandarin case). The English case seems closely linked with the use of the perfective as an inceptive marker for states in some languages (cf. §2.3.1) but I don't have an analysis for that here.

event (*stop* is a sort of anti-result). When this result is melded to an atelic predicate, the interpretation is equivalent to the finish function (which fits our intuitions: *Jenny finished singing* and *Jenny stopped singing* may be true of the same events) but when the stop result is applied to a telic predicate, the interpretation contains the entailment that the completion point wasn't reached (*Gunther stopped taming a tiger* ≠ *Gunther finished taming a tiger*). The entailment of non-completion arises because the melding process introduces the stop machine in place of the "finish" predicate. (The same thing happens in the resultative case, but there the result machine itself entails the completion point of the event.)[34] The stop result is illustrated in (124) for the telic sentence, *Gunther stopped taming a tiger.*

(124) Gunther stopped taming a tiger.



3.7. Tense

Tense is a function which operates over time intervals instead of over lexical aspect machines. One interval in time (called here t_0) plays a special role in tense definitions by acting as a deictic center and the tense functions are defined with respect to this point. The past, future and present tense are defined as follows:

(125) For an interval *i*
PAST (*i*) = {true, iff ∀*i*' *i*' ∈ *i*, *i*' < t_0, false otherwise)

(126) For an interval *i*
FUTURE (*i*) = {true, iff ∀*i*' *i*' ∈ *i*, *i*' > t_0, false otherwise)

[34] Given the discussion in Ter Meulen (1997), this analysis of *stop* may be a bit simplistic. An event which stops may resume again (something which doesn't happen with other resultatives) and this is a fact not captured here.

(127) For an interval *i*
PRESENT (*i*) = {true, iff PAST (*i*) and FUTURE (*i*) are false, false otherwise)

An interval therefore satisfies the past tense if all sub-intervals of that interval precede the deictic center and it satisfies in the future if the deictic center precedes all the sub-intervals of the interval. The present tense is the catch-all, accounting for all intervals which overlap with t_0 to any extent. No additional tenses need to be defined as the traditional complex tenses (e.g., the perfect and imperfect tenses) are analyzed here as conflating tense and grammatical aspect infromation into the same morpheme. This semantic analysis unpacks the separate contributions of the two and analyzes them separately through the tense and grammatical aspect functions.

Typically, t_0 is the time of utterance, but it may be assigned to other times. For example, the so-called historical present used in some narratives effectively re-assigns the t_0 to some time within the narrative. Sequence of tense phenomenon can also be analyzed as involving a shift in t_0. Recall from Chapter 2, following the insight of Enç (1984), that an embedded tense can be interpreted as temporally co-indexed with the matrix tense (when the two tenses match) or as temporally relative to the matrix tense. That is, sentence (128) can mean either (129a) or (129b).

(128) Rajesh said that Mona was pregnant.
(129) a. Rajesh said, “Mona is pregnant”
b. Rajesh said, “Mona was pregnant”

We implement Enç’s insights in the following manner. The matrix tense of a sentence must be evaluated with respect to the tense functions defined above. Any interval which is either equal to or a sub-interval of the matrix interval may, in English, use the same tense marker. That is, if the two intervals are essentially the same, they may be marked in the same way and thus the simultaneous reading (i.e., 129a) is accounted for. Some languages (Greek, Bulgarian, e.g.) apparently have a variation of this rule. In these languages, the equality of

intervals is indicated exclusively through the present tense (perhaps as part of a generalization of the overlap properties of the present tense) instead of through matching the tenses. Thus these languages must embed a present tense in order to get the simultaneous reading. Alternatively, the matrix tense may also re-assign t_0 to be equivalent to the matrix interval, in which case, any other tense in the sentence must satisfy the tense functions defined above with respect to the matrix-t_0. When t_0 gets shifted in this way, the embedded tense receives a backward shifted reading (i.e., 129b) since it is interpreted as past relative to the matrix time. This analysis leaves open the question of why optionality exists in these cases (why does the matrix tense only sometimes shift the t_0?) but it does account for the options that are manifested.

3.8. Connectives: Before, After, While, and When

In this analysis, temporal connectives such as *before*, *after*, and *while* are functions which define an ordering relationship between the time intervals associated with two events. The function for *after* orders the interval for the event described in the matrix sentence after the interval for the event in the subordinate sentence, *before* orders the events in the reverse manner, and *while* indicates that the two intervals are in fact the same interval. The ordering relations are specified in (130).

(130) for two time intervals m and s, where m is the interval associated with the matrix event and A(m) is the automaton operating over interval m, an s is the interval associated with the subordinate event and B(s) is the automaton operating over interval s,
AFTER (s, m) = {true iff A(m) = true, B(s) = true and m > s, false otherwise}
BEFORE (s, m) = {true iff A(m) = true, B(s) = true and m < s, false otherwise}
WHILE (s, m) = {true iff A(m) = true, B(s) = true and m = s, false otherwise}

Once the intervals have been ordered, the events are treated independently and their analyses do not interact with each other. The connectives require their sub-parts to be true (cf. the first condition in each definition) but they do not influence the running of the grammatical aspect or the lexical aspect machines. For example, in (131) *the clown juggled* and *the lions*

roared will be analyzed with respect to lexical aspect and grammatical aspect in exactly the same way, regardless of the temporal connective used. Temporal connectives operate much like the tense operators do, by simply restricting the time intervals that the Hold function may use to create the input string for the different predicates.

(131) The clowns juggled before/after/while the lions roared.

Despite the fact that the connectives do not influence the analyses of the sentences they contain, it is nevertheless true that the grammatical aspect of the different sentences can influence the overall interpretations of these sentences. In particular, when the temporally prior predicate (the matrix clause for *before* sentences and the subordinate clause for *after* sentences) is in the imperfective, it is possible to interpret it as extending into the time interval identified with the temporally later predicate. That is, both sentences in (132) can mean that the juggling act extended into the sword swallower's act.

(132) a. After the clowns were juggling, the sword swallower came on.
b. The clowns were juggling before the sword swallower came on.

The reason for this interpretation offered in Chapter 2 was that the imperfective is open with respect to its completion entailments and so allows for the possibility that the event continues beyond the boundaries of the time interval under evaluation. This explanation is tenable on the current analysis: the halting state for the imperfective function is not a coda state and in fact, the imperfective effectively specifies that the time interval under evaluation should complete before the event described by the predicate does. Therefore, whenever we interpret the time intervals ordered by the connectives as contiguous, common sense tells us that a priorly ordered imperfective predicate will have to extend its reference at least briefly into the later time period.

The situation with the connective *when* is a bit more tricky. As was discussed in Chapter 2, *when* allows for a direct interaction between the grammatical aspect of the predicates and the ordering imposed by the connective. That is, when the matrix clause is in the imperfective and the subordinate clause is in the perfective, the matrix clause is ordered first (133), but when the grammatical aspect values are reversed, so is the ordering (134).

(133) When Gunther cracked the whip, the lion was roaring
(134) When Gunther was cracking his whip, the lion roared.

This analysis has no way to account for an interval-ordering/grammatical aspect interaction like this one and so the analysis of when will have to remain an unsolved problem for the time being.

3.9. Chapter Summary

This chapter proposed a formal analysis of lexical aspect, grammatical aspect, and tense. The goals for this analysis were to provide a characterization of time that was (1) precise, (2) descriptively accurate and (3) computationally tractable. The first goal was clearly met; the advantage to working with formal objects such as automata is that their meanings are explicitly defined. The second goal was largely met. Many of the temporal phenomena discussed in Chapter 2 were accounted for with this analysis but by no means were they all accounted for. In part, this was the product of human time constraints (there are a lot of temporal phenomenon to be accounted for and I have only just begun) but, as we saw periodically in this chapter, in part this reflects some limitations of the analysis. Further research should address how to integrate temporal semantics with quantifier semantics more generally, provide a more complete account of the aspectual verbs and temporal connectives, and investigate the influence of pseudo-temporal notions such as causality. Finally, the third goal of computational tractability was met. By using only simple machinery, this analysis

reduced temporal semantics to a finite state problem, which are (from a computational point of view) very easily solved. A key advantage of being computationally responsible is that it permits this semantic analysis to be integrated into domains such as reasoning, processing, and acquisition where computational concerns are of central importance. It is in this spirit of computational integration that I now present the second half of this dissertation which addresses the question of how children acquire their temporal language.

Chapter 4. The Aspect First Hypothesis in Language Acquisition

This chapter reviews previous investigations into children's early acquisition of aspect and tense. It focuses on an intriguing distributional phenomenon that, as we shall see, has been found in the early speech of children acquiring a variety of languages. The phenomenon is this: initially, telic verbs appear almost exclusively with perfective or past morphological marking and atelic verbs appear with imperfective or present tense marking. That is, the distribution of the tense and grammatical aspect morphology appears to depend on the lexical aspect of the verb it is applied to[35]. For example, children acquiring English say things like *riding* and *dancing* (atelic verbs with the progressive/imperfective marker) and things like *broke* and *found* (telic verbs with past tense marking) but they don't say *danced* (atelic in the past perfective) or *breaking* (telic with the imperfective).

The extreme rarity of forms like *danced* and *breaking* seems quite odd: do children really never want to talk about an ongoing act of breaking (*Look Mom, I'm breaking my new toy!*) or past events of dancing (*We danced yesterday at Grandma's*)? This oddity has led some researchers to take a strong interpretation of these data, namely that they are not using tense and grammatical aspect morphology to mark tense and grammatical aspect information, but instead use them as markers of lexical aspect. This interpretation leads to what I will call the Aspect First hypothesis. My formulation of the hypothesis is given below. Note that this formulation is quite specific about what is being contrasted at the lexical aspect level (only the telicity-atelicity distinction) and at the grammatical aspect/tense level (always imperfective/present tense vs. perfective/past tense).

[35] The studies reviewed here focus primarily on the lexical aspect of verbs instead of on the more complete aspectual properties of the whole predicate. I will refer to the lexical aspect of verbs throughout this chapter, but will turn to the problems involved with ignoring the contribution of the whole predicate in §4.4.1.

Aspect First Hypothesis

> Children initially use tense and grammatical aspect morphology to mark lexical aspect. In particular, children initially use present tense and/or imperfective morphology to mark atelicity and use past tense and/or perfective morphology to mark telicity[36].

If the Aspect First hypothesis is correct and describes an early stage in child grammar, then it describes a genuine error (in fact, two errors) made by children. First, children err by marking something morphologically which they should not (telicity); and second, they err by failing to mark something which they should (tense and/or grammatical aspect). This would be a very interesting pair of errors for children to make because it involves children speaking a language which is unlike most (and perhaps all) adult languages in the world. Although lexical aspect is an important lingusitic category, it is rarely marked overtly and even in languages where it can be so marked, it is never marked across the board. On the other hand, tense and grammatical aspect are commonly marked morphologically and are among the very first elements that creole languages mark (Bickerton 1981, Bakker et al. 1995). The Aspect First hypothesis is worth investigating closely because if it is true, it represents quite an unusual stage of linguistic development.

This chapter will evaluate the production evidence from several languages with respect to this distributional phenomenon and discuss the implications of the Aspect First hypothesis. It will then motivate the experimental investigation of the Aspect First hypothesis to come in the following chapter.

[36] Which particular pieces of morphology are recruited for this distribution appears to depend on the particular language, with some languages contrasting past and present tense morphemes, others contrasting perfective and imperfective morphemes, and most contrasting some combination of conflated forms.

4.1. The Crosslinguistic Production Data

4.1.1. English

Bloom, Lifter and Hafitz (1980) looked at the development of verb inflections in four children, ranging in age over the investigation from 1;11 to 2;4. Looking at the verb suffixes *-ing*, *-s*, *-ed*/irregular (marking in the adult language progressive, 3rd singular, and past tense respectively) they found that initially most verbs were restricted to a single inflection and that the distribution of the inflections was dependent on aspectual properties of the verbs. Thus, verbs appearing with *-ing* were mostly durative and non-completive (atelic) while those appearing with *-ed*/irregular past were mostly non-durative and completive (punctual and telic). (Verbs appearing with *-s* were mostly stative; stativity will be discussed further in §4.1.6 below.) These results were in line with previous work of Sachs (1979) who had shown that her daughter Naomi initially (i.e., from 21-25 months old) restricted her past tense marking to events in the "immediate past", a category which was largely equivalent to having a current result state.

Bloom et al.'s verb classification system was based on a thematic (in the spirit of Case-grammar) analysis of the events which didn't directly incorporate notions such as telicity or completion. The fundamentally aspectual classification they end up with is driven by the distribution of the inflections[37]. Shirai and Anderson (1995) begin with an aspectual classification of the verbs to see if this information will predict the distribution of the inflections. Shirai and Anderson investigated the speech of three children ranging in age from 1;6 to 4;9. They classified all the verbs according to the Vendler (1967)/Dowty (1979) verb classes and then examined the use of inflections (*-ing*, and *-ed*/irregular past) with respect to those classes. In essence, they replicated Bloom et al.'s finding: initially, children use the progressive *-ing* with activities (which are durative and non-completive) and the past

[37] In some cases, it is too driven. For some verbs, such as *write* and *eat*, which are ambiguous with respect to their aspectual classification, Bloom et al. use the fact that these verbs appear predominantly with

tense marking with telic verbs. This distribution of inflections according to aspectual class diminishes with age so that children at the older stages are using different inflections with different verb types.

Olsen et al. (1998) has provided some of the strongest support for the validity of the distribution. In one of the most thorough examinations of English production data, they classified all the verbs of 8 children from the CHILDES data base from the ages of 1;4 to 5;1 according to the aspectual features of Olsen (1994)[38]. They found that for the youngest group of children (with an MLU of 2.5 words or less), over 90% of the inflected telic verb tokens appeared in the past tense and over 90% of the inflected atelic verb tokens appeared with the progressive *-ing*. Moreover, it does not appear that the token data is driven primarily from only a very few number of verb types (Olsen et al. provide examples using a variety of verb types). As with the other studies, the strength of the distribution diminished as children's MLU increased.

Smith (1980) tried to find some counter-evidence to the claim that children don't use past tense marking with incompletive events (it appears from her discussion that she means both atelic verb types and perhaps also events in the imperfective viewpoint). She examined the utterances of 17 children ranging in age from 2;5 to 5;8 looking for instances of past tense marking on atelic events. She finds a large number of them (for the older children, more than 40% of past tense marking appears on such events) but, despite her arguments, these examples don't constitute counter-evidence to the studies just reviewed or any of the data to be discussed below. The tendency to restrict past tense marking to telic verbs declines with age (cf. Shirai and Anderson 1995 and Olsen et al. 1998 especially but also Bloom et al. 1980) and the youngest children Smith looked at were 2;5 -- which is older than any of the children Bloom et al. looked at. Moreover, there is a clear age effect in Smith's own data: all

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-ing as the reason to classify them as non-completive. See Rispoli and Bloom (1985) and especially Smith and Weist (1987) for further discussion.

of the children who use fewer than 25% of their past tense marking on incompletive events are in the young age group[39].

The production data in English, therefore, shows in general a distributional bias of inflectional forms according to the telicity of the verb and this distribution is consistent with the Aspect First hypothesis.

4.1.2. Romance Languages

Bronckart and Sinclair (1973) used an elicited production task to investigate **French** children's early use of verbal inflections. They presented children between the ages of 2;11 and 8;7 with a series of events and asked them to tell about each one. The scenes varied as to whether they had a clear result (e.g. a car hitting a marble vs. a fish swimming around in a basin), the duration of the event (0.5 to 15 seconds), whether the event was repeated or continuous (a cow jumps over 5 fences or only over 1), whether the event was a success or not (the horse reached the stable or didn't) and the mode of presentation (3 events were presented auditorially -- e.g. a sheep bleating -- and the rest visually). Up to the age of about six, children tended to use the present tense when describing events with no clear result and the past perfective form (the passé composé) when describing events which had a clear result. The auditorially presented events, which Bronckart and Sinclair class as being neutral with respect to a result state, were described in almost equal proportions with past perfective and present forms. These findings are consistent with the Aspect First hypothesis in that the children are distributing verbal inflections (in this case, present and past) according to lexical

[38] Olsen (1994) adopts a feature based analysis of language using three privative features: telicity, dynamicity, and durativity. The privative quality of these features causes her to group some predicates slightly differently from the traditional Vender/Dowty classification but the differences are not relevant here.
[39] Smith (1980) also argues that there is a potential underestimation of children's competence with tense in English caused by the fact that most of the utterances contain only 2 or 3 words. She notes that the imperfective (the progressive) forms that children are using in English usually omit the auxiliary verb where the tense is marked (i.e., they say *Mommy dancing* omitting the auxiliary *be*). Thus it is possible that these children do put atelic verbs in the past tense, we just don't see the tense marker in those cases.

aspectual types: atelic events appear with the present tense and telic events appear in the past tense[40]. Given that all the events described in fact happened in the past (by virtue of the experimental design) it is quite striking that children used so many present tense forms.

One troubling element to Bronckart and Sinclair's results is the fact that the distribution of inflections by verb type persists until the children are quite old (approximately until age six). The source of this difficulty may have to do with children's early troubles with the past imperfective form (the imparfait) in French. In the experiment, children were using the present tense forms where adults would normally use the past imperfective form. Moreover, children in this study didn't begin to use the past imperfective form until the age of six. Smith (1980) notes that children have been recorded using the past imperfective form as young as four years old, but that doesn't preclude the possibility that Bronckart and Sinclair's subjects didn't know it. Thus it may be that the data does not support the Aspect First interpretation so much as demonstrate the pitfalls of French morphology. However, the fact that the imperfective past form comes in comparatively late is interesting in itself; even more interesting is the fact that children chose to use an inappropriate tense marker for those cases, rather than collapse them with the events in the past perfective. Although not compelling by itself, Bronckart and Sinclair's study is at least not inconsistent with the Aspect First interpretation.

Antinucci and Miller (1976) looked at speech from seven **Italian** children from the ages of 1;6 up to 2;5. They classified all the verbs used in terms of the following aspectual categories: states, change of state with clear result (i.e. telic), activity/change of state with no

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Of course, even if that were true, it is still the case that most atelic verbs occur in the imperfective (whether past or present) and very few telic predicates do.

[40] It appears from Bronckart and Sinclair's discussion that telic and atelic events were described using telic and atelic predicates repsectively but they don't seem to test for this directly or report any statistics establishing such a correlation. Some of the interesting wrinkles in the data, such as the the fact that telic events of long duration saw a significant rise in the number of present tense forms, or the fact that auditorally presented events split evenly across present and past tense forms, might be explained by a closer examination of the properties of the predicates uttered in addition to the properties of the events watched.

result (i.e. atelic) and other. Looking at the distribution of verbal inflections, they found that the verbs with a clear result appeared in the periphrastic past form (the passato promisso) and that verbs from the other classes only very rarely did. The activity verbs appeared with imperfective marking (imperfetto), though such marking was found only for the older children in the study. These children apparently also showed an unusual agreement pattern in the past: they made the past participle agree (in number and gender marking) with the object of the sentence instead of the subject as adults would. Antinucci and Miller argue that the children are focusing on the result or end state of the event and that the transitive object is a better indicator of that state (cf. the role of the direct object in aspectual composition, §2.2.4) and hence determines the agreement of the participle for the child. This Italian data, therefore, appears to strongly support the Aspect First interpretation of children's early use of inflections.

Additional data on early knowledge of aspectual distinctions has been documented in Brazilian **Portuguese** (de Lemos 1981) and **Catalan** (Llinas i Grau 1997). In Brazilian Portuguese, de Lemos looked at the speech of three children ranging in age from 0;8 to 2;5. She found that they restricted their "perfective tense" inflections to telic events and progressive forms to atelic events. Grau (1997) reports on the speech of one child learning Catalan from the ages of 1;9 to 2;1. She finds an unusual pattern in which verbs of different aspectual types distribute over different word orders. Thus, although both telic and atelic verbs appear in VO word order, only telic verbs appear in OV word order. This finding is somewhat reminiscent of the Italian agreement facts in which telic verbs appear with object agreement. Both the Portuguese and the Catalan data are consistent with the Aspect First interpretation.

4.1.3. Other Indo-European Languages

Weist, Wysocka, Witkowska-Stadnik, Buczowska, and Konieczna (1984) conducted an analysis of the speech of six children aged 1;7 to 2;2 acquiring **Polish**. They classified the children's verbs according to lexical aspectual type and examined the distribution of tense and grammatical aspect morphology with respect to those types. Polish is different from the languages discussed so far in that it has separate morphological markers for tense and grammatical aspect. It therefore allows for a more precise analysis of what kinds of morphology the children are distributing across the lexical aspectual types. Weist et al. found an ample number of cases in which the children used past tense morphology with atelic verb types (and even with atelic verb types combined with imperfective aspect morphology) as well as cases where the children used telic verbs with imperfective aspect morphology and with the present tense. They concluded from these cases that Polish did not demonstrate the distribution found in other languages and provided no support for the Aspect First hypothesis. However, Bloom and Harner (1989) re-examined Weist et al.'s data and came to a different conclusion. Bloom and Harner argued that it was possible to find a general tendency in a data set even if there exist a certain number of counter examples to that tendency. If we consider the distribution of morphology in Polish from a statistical point of view (instead of a categorical one), it turns out that atelic verbs were much more likely to appear in the present tense than the past tense (424 present tense examples to 45 past tense ones) while telic verbs were more likely to be in the past tense (63 present tense examples to 265 past tense ones). Moreover, among verbs marked for past tense, telic verbs were more likely to be doubly marked as being past and perfective (252 examples) as opposed to being marked for past and imperfective (13 examples). For whatever reason, perhaps on account of the transparent encoding of grammatical aspect and tense morphology, the restriction of tense and grammatical aspect markers to verbs of particular aspectual types is weaker in Polish than in

other languages. Nevertheless, Bloom and Harner have demonstrated that it still exists and to the extent that it does, it supports the Aspect First hypothesis.

In addition to their corpus work, Weist et al. (1984) also report an elicited production study conducted with children aged 2;4-3;11. They used a similar paradigm to that used by Bronckart and Sinclair (1973) with one exception: their instructions to the children to retell the scene contained the tense and grammatical aspect morphology that the adult-like answer would contain. Under these circumstances, they find that children indeed sound rather adult-like, using, for example, a high percentage of past tense morphology with atelic verbs and imperfective morphology with telic verbs. The rationale for this kind of experiment is that children will not utter sentences incompatible with their grammar; the purpose of the cue is to help them utter less salient (though perfectly grammatical) forms. However, given that the children have a productive command of all the morphology and that periodically they in fact do say the less salient pairings (this is a statistical, not categorical, phenomenon), it's not that surprising that children can be pushed into succeeding on this task. The real question is what the children think the forms mean. In particular, do they appreciate the difference in meaning between the combinations they usually say and those they say only rarely? This experiment does constitute a counter-example to the Aspect First hypothesis but it is not a hugely compelling one.

Stephany (1981) examined the acquisition of verbal morphology in the speech of four children aged 1;8 to 1;9 acquiring Modern **Greek**. In Greek, tense and grammatical aspect information are marked through a combination of verb stem choice and inflectional ending. Modality is marked through a particle. Stephany found that the children only produced three combinations of this morphology: the non-modal imperfective (consisting of the present/imperfective stem and present tense inflection), the non-modal perfective (consisting of the aorist/perfective stem and past tense inflection) and the modal perfective (consisting of the aorist/perfective stem and present tense inflection). In the adult language,

these three forms would convey, respectively, the present imperfective, the past perfective, and with the addition of the proper modal particle, the future tense. Although these children are restricting grammatical aspect and tense marking with respect to each other, the distribution of these forms over verbs of different lexical aspectual classes does not form the same picture seen in other languages. Stephany classified the children's verbs according to three lexical aspectual classes: stative, resultative (telic), and non-resultative (atelic). While the stative verbs appeared overwhelmingly in the non-modal imperfective morphological combination, the telic and atelic verbs patterned largely together, both appearing most frequently in the modal perfective form. Given the formulation of the Aspect First hypothesis adopted here, Greek presents a genuine counter-example to it: telicity is not the determining factor for the tense/grammatical aspect morphology. However, the Greek data constitutes quite an interesting counter-example for two reasons. First, lexical aspect is playing a role in determining grammatical aspect/tense morphology in the form of stativity. This is somewhat different from what is happening in other languages, but it raises the possibility that a wider conception of the Aspect First hypothesis might find even broader crosslinguistic support. Second, this data suggests another dimension to be investigated, namely, the way that children might initially treat grammatical aspect and tense as dependent on each other (irrespective of lexical aspect information). This question will be addressed further in §4.2.

Behrens (1993) examined the utterances of seven children from age 1;3 to 3;0 acquiring **German**. She only looked at their use of past tense morphology (that is, their use of the past participle with or without its auxiliary verb) but she found that the past tense was largely restricted to telic predicates for children under the age of 2;8. The German data is therefore consistent with the Aspect First hypothesis.

4.1.4. Non-Indo-European Languages

Aksu-Koç (1988) examined the development of the verbal inflectional system in **Turkish**. She studied the speech of three children from age 1;9 to 2;6. She found that initially, the past tense marker (-dI) was restricted to punctual and completive (telic) verbs and the present progressive marker (-Iyor) was used with durative verbs. Thus Turkish shows the familiar distribution of morphology by verb type and is consistent with the Aspect First interpretation.

Berman (1983) reports on the data from hundreds of children acquiring **Hebrew**. She finds that around the age of 2, children generally restrict telic verbs to the past tense form and atelic verbs to the present tense. Armon-Lotem (1997) found a similar pattern in her study of a child acquiring Hebrew from the ages of 1;7 to 2;4. Berman's investigation has also uncovered one of the few actual errors children make in this area. Hebrew verbs are inflected through one of several morphological templates, or binyanim. In the nif'al binyan, there is no distinction made between the past and present tense forms -- the relatively few verbs that are conjugated through this binyan have their tense value determined by context. Children, however, apparently don't like the ambiguity and over-generalize a present tense marker (the prefix *m*-) used in other binyanim for verbs in the nif'al binyan. Most interesting is the fact that this incorrect extension of the prefix only occurred with atelic verbs; telic verbs in the nif'al binyan did not occur with the incorrect present tense marking. Thus, the Hebrew data supports the Aspect First interpretation.

In **Japanese**, the evidence relating to the Aspect First interpretation is somewhat mixed. Clancy (1985), in her review of Japanese acquisition data, reports that Japanese children initially restrict verbs to a single verbal inflection and that these inflections do seem to distribute over the verbs according to their verb class. The data from a single Japanese

learning child (from age 1;6-2;1) investigated by Rispoli (1981) showed that the past tense marker (*-ta*) was initially restricted to telic verbs (cf. also the discussion of Rispoli in Anderson and Shirai 1996). Cziko and Koda (1987) however analyzed the speech of a single Japanese child from the ages of 1;0 to 4;11 and found no evidence that children were using morphological markers to distinguish between resultative and non-resultative verbs, nor between punctual and non-punctual verbs. A re-analysis of Cziko and Koda's data reported in Anderson and Shirai (1996) claims to find that in fact the past tense marker is restricted to achievements and the progressive/continuative marker (*-tei*) appears with activities. Tentatively, then, it appears that Japanese is consistent with the Aspect First interpretation.

Li (1990) conducted an elicited production task with chidlren aged 3 to 6 years old acquiring **Mandarin Chinese**. The children were asked to describe scenes acted out using the same procedure as Bronckart and Sinclair (1973). Li then identified the lexical aspect of all the verbs produced and examined how verbs of different lexical aspect categories were distributed with respect to three grammatical aspect markers: *-le* (a perfective marker), *zai* and *-ne* (both imperfective markers). The results showed the familiar Aspect First pattern. Resultative and telic verbs appeared over 90% of the time with *-le* (perfective) for children at all ages and process (atelic) verbs appeared with one of the imperfective markers (*zai* or *-ne*) about 70% of the time for children aged 3, 4 and 5 (and about 92% of the time for 6 year olds). Punctual and stative verbs patterned with the atelic verbs, though not quite as strongly. Despite the strength of this finding, it is unclear whether it consititutes genuine support for the Aspect First hypothesis. Mandarin is the only language found where the distributional pattern gets stronger with age: the oldest children in Li's studies showed a stronger bias to distribute their grammatical aspect morphemes according to the lexical aspect of the verb than the youngest children, and the youngest children (around 3 years old) were already older than many of the children examined in previous studies. We can make sense of the increasing strength of the distribution with age through Li's comments that in adult Mandarin

the pairing of a telic verb with an imperfective marker (or an atelic verb with a perfective marker) is extremely unnatural, though apparantly not altogether impossible. That is, as children get older they distribute their morphology in ways that are more adult-like, but in Mandarin (perhaps unlike the other languages studied, though see §4.4.4) the adult language happens to manifest the Aspect First distribution itself. Thus, the Mandarin data is certainly consistent with the Aspect First hypothesis, but given Li's intuition about adult Mandarin, this fact doesn't have the same explanatory force that it does for other languages.

4.1.5. Summary of the Crosslinguistic Data

The Aspect First hypothesis says that initially children use the lexical property of telicity as a determinant of tense/grammatical aspect morphology. This hypothesis finds support when children distribute this morphology according to the lexical aspect of the verb. That is, when children restrict past or perfective morphology to telic verbs and present or imperfective morphology to atelic verbs. Looking at children's early production data, we find support for this hypothesis in English, Italian, Brazilian Portuguese, Turkish, and Hebrew. Additional, though somewhat weaker support comes from French, Catalan, Polish, German, Japanese and possibly also Mandarin. Of the languages examined, only Modern Greek showed a pattern in which the children did not distinguish between telic and atelic verbs morphologically.

4.1.6. Stative Verbs

Several of the preceding studies considered the lexical property of stativity in addition to telicity, but I have left stativity outside of the Aspect First hypothesis. One reason for this omission is the fact that in some of these languages, lexical stativity is, even for adults, a determinant of morphological marking. For example, in early child data from

both English (Brown 1973) and Japanese (Cziko and Koda 1987), stative verbs virtually never appear with the progressive marker (*-ing* in English, *-te iru* in Japanese). Moreover, Bloom et al. (1980) found the 3rd person singular present marker *-s* appearing almost exclusively with stative verbs and Olsen et al. (1998) found stative verbs receiving inflection of any kind significantly less often than non-statives. Note, though, that in both English and Japanese, the adult language does not (or at least not normally) permit statives with the progressive and furthermore, that in English, only stative verbs can appear with simple present tense marking (i.e., *-s*) without receiving a habitual interpretation. Typically in English, statives appear in a form identical to their bare stem. It is not uninteresting that languages allow stativity to restrict morphological marking, nor is it uninteresting that children make few errors when languages do. However, it is impossible to tell in these cases if children are applying a bias of their own (perhaps, look at lexical aspect above all) or simply being sensitive to the grammar of the language they are acquiring.

The data from Greek (Stephany 1981) shows the children making a distinction with statives where none exists in the adult language. The children restricted stative verbs largely to having non-modal imperfective marking but Greek allows statives to appear with several other stem and inflectional combinations. This is the kind of data that would lead one to believe that children are using stativity on a par with telicity as a determinant of verbal morphology. However, since Greek is the only language which demonstrates this pattern (and interestingly, the only language which does not demonstrate the telicity bias), there is insufficient warrant for broadening the Aspect First hypothesis to include stativity.

In the remaining studies that examined stativity (Italian, Portuguese, Polish, Mandarin), the stative verbs behave like atelic verbs: they don't appear with past or perfective marking but usually do appear with present or imperfective marking.

4.2. Characterizing the Aspect First Hypothesis

Within the literature, there has been a fair amount of confusion and some disagreement about how to characterize the distributional phenomenon discussed here. To properly understand the data, there are four levels that must be recognized: tense, grammatical aspect, lexical aspect, and the events happening in the world. Tense and grammatical aspect are independent grammatical markers which add time and perspective information respectively into a sentence; lexical aspect describes the inherent properties of the predicate. These three linguistic categories are used to describe events in the world, but events themselves underdetermine their linguistic description -- a single event may be described in many possible ways. There are three sets of confusions among these levels which crop up.

First, there is the confusion between tense and grammatical aspect. Bronckart and Sinclair (1973) and Antinucci and Miller (1976) both characterized the morphology used as tense morphology (leading to the name for the phenomenon in Weist et al. 1984 of the "defective tense hypothesis"). However, in both these early studies (and most subsequent ones), the relevant morphology actually consists of conflated forms which contrast both tense and grammatical aspect information. For example, in French, children contrasted a past tense perfective marker (the passé composé) on the one hand with a present tense imperfective marker (the présent) on the other[41]. The distribution involves similarly conflated forms in English, Italian, Japanese, Portuguese and Turkish. Thus there is as much cause in most cases for saying the children are mis-using grammatical aspect morphology as tense morphology. Even in a language like Polish, in which tense and grammatical aspect are distinct morphologically and which therefore could in principle supply the evidence needed to determine if this phenomenon really concerned tense or grammatical aspect, we find children

[41] Smith (1991) has presented evidence that the present tense in French may actually be under-determined for grammatical aspect, allowing both perfective and imperfective interpretations depending on the context.

distributing both past tense and perfective morphemes with the telic predicates and both present tense and imperfective morphemes with the atelic verbs. In the end, it may turn out that the right characterization of the morphology differs from language to language (that is, in French children might be mis-using the tense morphology while in Italian they might be mis-using the grammatical aspect morphology) but this question cannot even be raised unless we acknowledge that there are two concepts being conflated in these forms.

The second confusion involves grammatical aspect and lexical aspect. As discussed at length in Chapter 2, these are distinct linguistic elements that cover distinct, though related, concepts. Traditionally, there has been great terminological confusion between the two kinds of aspect which is sadly present in the current literature (most glaringly, Smith 1980 uses the terms "imperfective" and "perfective" for both grammatical and lexical aspect while Bickerton 1981 uses "punctual" and "non-punctual" for both). Bickerton's unfortunate terminology has led to some confusion about the status of creolization with resepct to the Aspect First hypothesis. Bickerton (1981) argues that the punctual/non-punctual distinction is part of the bio-program and as such is made by creoles as well as by two year olds. He claims that the results from Bronckart and Sinclair (1973) and Antinucci and Miller (1976) demonstrate children making the puncutal/non-punctual distinction, even if they don't use the right morphology for it. However, as he makes quite clear in Bickerton (1989), Bickerton intends the punctual/non-punctual distinction as a grammatical aspect distinction (i.e., the perfective/imperfective distinction) and his claims about acquisition are based on his re-analysis of the earlier data in terms of grammatical aspect. That is, Bickerton believes (and believes the data show) that children mark grammatical aspect before they mark tense. With respect to lexical aspect, Bickerton argues that the state-process distinction is part of the bio-program but makes no claims at all regarding telicity. Empirical investigation may show that Bickerton is ultimately correct about how to properly characterize the child data (there seems to be only minor questions about his characterization of the creole data, cf.

Bakker et al. 1995) but few of the acquisition studies reviewed here have data relevant to the grammatical aspect distinction Bickerton wants to link to the creole data.

In addition, by neutralizing the distinction between the two kinds of aspect, researchers have also overlooked what may be a distinct phenomenon in acquisition, namely, children's potential early confusions between tense and grammatical aspect. The data from Greek (Stephany 1981) and Polish (Weist et al. 1984) suggest that children may not have separated present tense from imperfective aspect on the one hand nor past tense from perfective aspect on the other, regardless of how they distribute these combined meanings over lexical aspectual types (they distribute by stativity in Greek and by telicity in Polish). In addition, the late appearance of the past imperfective form in French (the imparfait) reported by Bronckart and Sinclair may also be a symptom of a tense-grammatical aspect confusion that is occurring independently of lexical aspect. Given the morphological and historical connections between grammatical aspect and tense, initial acquisition difficulties with these two seems more plausible and may have longer lasting effects than a confusion of either of the two with lexical aspect. But again, it is only by clearly distinguishing lexical aspect from grammatical aspect that we can separate these questions and ask what is really going on in acquisition.

A final confusion in the literature involves the application of linguistic categories to the real world. Most of the studies reviewed here categorized the lexical aspect of children's verbs and examined how morphology was distributed with respect to those classes. They were interested in how one linguistic category (lexical aspect) influenced the presence of another (grammatical aspect or tense). The primary exception was Bronckart and Sinclair (1973) who presented the children with actual events and examined how the morphology was distributed with respect to properties of the events presented. No doubt because of the simplicity of the events presented, Bronckart and Sinclair appear to get a strong consensus as to what predicates should be used to describe the event, and even when there is disagreement among the subjects (children described a duck that swam in a circular basin using at least the

verbs *float*, *play*, *sail* and *swim*) there appears to be consensus on what lexical aspect to use to describe the event. The consensus of how to describe the events at a lexical aspect level is what allows us to compare these results to the other studies, because in principle Bronckart and Sinclair are concerned with a different issue, namely, how the world (and not a linguistic category) influences the presence of linguistic morphology.

The reason this is such a pernicious confusion is that in point of fact, the world should influence the kind of linguistic morphology we use. Consider, for example, a case discussed in Shirai and Anderson (1995). They note that one of the exceptions to the Aspect First distribution pattern involves the verb *jump*. According to their classification system (as well as the one used here in Chapter 2), *jump* is telic and is therefore expected to appear in the past tense in early child English, as *jumped*. What they find, however, is that *jump* usually appears in the progressive, as *jumping*, thus aligning itself with the atelic verbs. To account for this disparity, Shirai and Anderson turn to the world. They note that from extra-linguistic context, it appears that *jumping* is being applied to iterative instances of jumping, which means the verb is really being applied to an atelic event from the world (ongoing jumps) and the pattern is preserved. The problem with this approach is that telic predicates (particularly punctual ones like *jump*) often receive iterated interpretations in the imperfective. That is, the semantic contribution of the imperfective when applied to a punctual predicate is to indicate that in the world, the event described by that predicate is iterated. The fact that the children put a punctual predicate like *jump* in the imperfective for just those cases when the world presents them with an iterated set of jumps suggests that they understand precisely the semantic contribution of the imperfective. The choice of grammatical aspect should be independent of the lexical aspect of the predicate; it shouldn't be independent of the event being described. We risk grossly underestimating children's competence with grammatical aspect and tense if we insist on treating lexical aspect as the only part of language which codes information from the world.

Let me be clear, then, about what the Aspect First hypothesis means here. It states that children are confusing two linguistic levels: they are using lexical aspect as a determinant for morphology that for adults, expresses either grammatical aspect, tense, or both. The Aspect First hypothesis is in principle agnostic about whether it is tense or grammatical aspect morphology (or some combination) that is at issue, because both crucially differ from lexical aspect by being independent elements which contribute meaning to a sentence while lexical aspect simply describes the information already inherently present in the predicate. The acquisition order of tense and grammatical aspect, and the linguistic connection between lexical aspect and grammatical aspect are questions closely related to the Aspect First hypothesis (they may even be, in some cases, the questions that the research reviewed here intended to address) and I will discuss them briefly in the chapters that follow; they are not, however, the central concern of the research presented here.

4.3. Explanations of the Aspect First Hypothesis

This section will consider some motivating explanations for the Aspect First hypothesis and for the distributional phenomenon more generally. The first three explanations (conceptual development, syntactic development and linguistic mapping) are all intended to explain the Aspect First hypothesis itself; they address the question of what would cause a child to mark telicity at the expense of tense and grammatical aspect. The last two explanations (UG constraint, semantic affinity) present alternatives to the Aspect First hypothesis analysis of the distribution; they address the question of why a child would show this distributional pattern if the Aspect First hypothesis weren't true.

4.3.1. Conceptual Development

Early research on the Aspect First Hypothesis was done explicitly within a Piagetian framework (Bronckart and Sinclair 1973, Antinucci and Miller 1976) and their explanation of the phenomenon was based on Piaget's ideas of cognitive stages and conceptual development (Piaget 1969, Levin 1982). On Piaget's theory, time is not a concept initially available to the child but event properties may act as a kind of time substitute. As Levin (1982) puts it, "the intuitive child [age 4-5] does not distinguish between the abstract dimension of time and the events that occur during that time."

A related proposal has come out more recently. Shirai and Anderson (1995) are not Piagetian but they have argued for what they call a "prototype theory" of concept development in this area. They claim that the prototypical meanings of pastness, perfectivity and telicity are the same (a completed event done to completion in the past -- the past requirement is presumably so the completion can be properly evaluated as such). Children begin with this prototype as the meaning for the relevant morphology and from it learn to differentiate the separate meanings of past, perfective and telic. Thus, children must shift conceptually from a general completive/past notion to several more particular concepts. Shirai and Anderson (1995) and Anderson and Shirai (1997) are a little vague about how one can learn the concept of pastness from the concept of completion. Telicity plays a key role in the process since the results of a telic event may persist into the present, thus crucially highlighting the relationship between the past and the present and perhaps providing a bootstrap from lexical aspect to tense and grammatical aspect. However, as discussed at length in various parts of this dissertation, lexical aspect, grammatical aspect, and tense are independent sources of information and are not derivable from each other (and see Fodor 1975, Fodor 1981 for principled problems to this approach in general). The prototype account is plausible only if accompanied by some sort of conceptual change which alters the hypothesis space for the child.

4.3.2. Syntactic Development

Recent investigations into acquisition of syntax have suggested that children may not initially create complete (from the adult perspective) trees for their sentences (e.g. Vainikka 1993, Rizzi 1997)[42]. The absence of inflectional marking in early child language is a reflection of the fact that these children don't have the functional projections in their trees to support such marking. The Aspect First hypothesis suggests a related strategy: instead of omitting inflections that they can't support syntactically, children may assign the inflection to a lower projection. Lexical aspect is computed across the VP which is a syntactic level these children do have access to (they would need a VP to produce verbs and arguments at all)[43]. Having noticed the relevant morphology, children are doing their best with the syntactic tools they have available to them and using the morphology to mark properties of the lower projection. As children mature, their syntactic facility increases and they are able to properly use the morphology.

This explanation is compatible with the conceptual development explanation; it may be that children's syntactic development depends on their conceptual development. Given the fact that the information associated with higher projections tends to be of a more abstract nature, such a directed connection does not seem implausible. However, syntactic development is not necessarily tied to conceptual development and the time course of syntactic maturation may operate independently.

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[42] The competing view of syntactic development, articulated most prominently by Wexler (1990) states that children have access to the entire tree from the beginning. However, with respect to the current phenomenon this difference amounts to very little since Wexler still advocates a maturational process for the features on that full tree, with younger children failing to fill (or only optionally filling) several of the higher projections, such as tense.

[43] Even theories (e.g. van Hout 1998) which assign telicity to a projection outside of the VP still put telicity in a projection below the one used for tense and/or grammatical aspect information.

4.3.3. Linguistic Mapping

We know that languages differ widely in how they encode tense, grammatical aspect, and lexical aspect information (cf. Smith 1991, Dahl 1985, Comrie 1976) so language particular encodings of this information are things that must be learned by the child. The linguistic mapping explanation states that the Aspect First data reflects an initial incorrect guess as to how to map tense and grammatical aspect concepts into the morphology. The focus on lexical aspect at the expense of tense and grammatical aspect reflects a mapping bias (and one of some interest) of the type proposed by Slobin (1985) but does not reflect a conceptual deficiency.

The Distributional Hypothesis of Shirai and Anderson (1995; also Anderson and Shirai 1997) is also relevant to the linguistic mapping explanation. Shirai and Anderson (1995) argue that children's distribution of forms essentially mimics the input they hear (cf. §4.4.4). To the extent this is true, it will make the mapping problem more difficult. In order for children to learn what concepts go with which pieces of morphology, they need linguistic evidence that distinguishes between lexical aspect and grammatical aspect/tense. If the input is scarce with such examples, learning will be slow and children will produce data consistent with the Aspect First hypothesis.

4.3.4. UG Constraint

Olsen et al. (1998) have argued that the Aspect First data reflects children's obedience to the subset principle (cf. Wexler and Manzini 1987, J.D. Fodor 1992). They note that languages exist which restrict perfective marking to telic predicates and imperfective marking to atelic predicates (they cite Chinese as a language with a relevant restriction of an imperfective marker to atelic predicates). Such languages therefore have a subset of possible forms compared to the forms available in a language like English, which

permits perfective and imperfective marking to be applied to predicates of all aspectual types. Olsen et al. accept that children must obey the subset principle and therefore initially posit the more restricted language until positive evidence forces them into the superset language. On this account, children have full conceptual grasp of grammatical aspect and even know how to correctly map these concepts to the morphology. What they don't yet have is enough positive evidence to trigger them to the superset language. Shirai and Anderson's (1995) data on the distribution of forms in the input (mentioned in the previous explanation) also serves a function in this explanation in that it explains the scarcity of positive evidence. It is unclear how well this explanation can account for the alignment of tense and lexical aspect (no languages as far as I know restrict past tense to telic predicates) but given the conflation of tense and grammatical aspect in the languages so far studied, it is also unclear how big a problem that is.

4.3.5. Semantic Affinity

A final possible explanation for the distribution data is that there is no developmental or acquisition phenomenon to be explained here at all. There is no disagreement that the meanings of telicity and perfectivity are alike in some intuitive way. Comrie notes that we can even think of grammatical aspect and lexical aspect as the encoding of the same information in two different domains -- the grammar and the lexicon. Moreover, we know from the way languages change historically (Bybee et al. 1994) that perfective markers and tense markers are often derived from one another. The fact that children line up these conceptually related categories may mean only that they have appreciated these semantic affinities. That is, children may demonstrate the distribution of forms consistent with the Aspect First hypothesis despite the fact that they fully understand the concepts, know how they are encoded in their language, and have even learned the extent of their target language's restrictions on the use of these forms. This explanation says that there may be a

phenomenon to be explained here, but the explanation should come from the fields of semantics or historical linguistics and not the field of language acquisition.

4.3.6. Breaking down the explanations and their presuppositions

These explanations rely on our ability to draw conclusions about children's grammars from the production data, though the conclusions we are forced to rely on are steadily weaker as we go through the explanations. Thus the conceptual and syntactic development explanations as well as the linguistic mapping explanation commit us to the following proposition:

(a) children are in fact **not** using the tense/grammatical aspect morphology to mark what it marks in the adult language

More positively, these explanations, particularly the conceptual and syntactic development explanations, commit us in addition to the following proposition:

(b) children are using the tense/grammatical aspect morphology to mark the telic-atelic distinction

If proposition (b) is a warranted conclusion, than (a) is as well but the reverse is not the case. The linguistic mapping explanation, for example, is committed to (a) but is in principle agnostic about (b): if the children are using the morphology to mark something other than telicity or nothing at all it still makes sense to talk about them needing to learn the proper mapping of concepts to morphemes.

The UG constraint explanation is not committed to either proposition (a) or (b) but is committed to the somewhat weaker (c):

(c) children consider the combination of event types and morphology that they do not produce as ungrammatical. That is, atelic predicates with perfective/past marking and telic predicates with imperfective/present marking are not part of their grammar

If proposition (c) is not correct then all the explanations (except for the semantic affinity explanation) lose their foundation. In order for there to be something to explain, the scarcity of certain forms in the child's production must be indicative of the child's grammar. There are reasons, however, to be skeptical of this interpretive leap.

4.4. Difficulties with Interpreting Production Data

In an earlier section (§4.1.5) I have argued that, insofar as the data based on children's production can support the Aspect First hypothesis, it does so. In this section, I will argue that no matter how strongly the production data supports the hypothesis, it alone can not convince us that we are gaining access to the child's grammatical competence. There are several major difficulties in using production data to evaluate the Aspect First hypothesis which I will now consider.

4.4.1. The problem of classifying the aspectual classes of the verbs

The Aspect First hypothesis depends on our ability to accurately classify a child's verbs according to lexical aspectual type. Aspectual class, however, is not a property of verbs alone, but is a property of whole predicates (cf. §2.2.4 for a complete discussion of aspectual compositionality). Changing the object of the verb *eat* from a count noun (*a sandwich*) to a mass noun (*peanut butter*) changes the aspectual class of the predicate from telic to atelic. In order to be sure what aspectual class a child intends, we need to have access to the entire sentence. Unfortunately, few children in the relevant age range consistently produce complete sentences (some of the children studied were still in the one-word stage). Researchers have attempted to solve this problem by using contextual cues to figure out what the child intended but this is an inherently unreliable method. Context will always under-

determine the possible linguistic encodings: the same glob of peanut butter can be referred to as either *peanut butter* or *a glob of peanut butter* with concomitant changes in the telicity of the sentence. Without knowing for sure what lexical aspectual types the children are using, we cannot be sure there is a distributional pattern here to account for at all.

4.4.2. The problem of uninflected forms

The Aspect First hypothesis is concerned with distribution of inflections. However, most of the verbs children use are not inflected. Bloom et al. (1980) reports that initially children are using inflections in only 19% of the relevant contexts and that even the older children in her study are only using inflections 54% of the time[44]. Olsen et al. (1998) found that statives appear inflected significantly less often than non-statives, but even non-statives were only inflected 53% of the time for the lowest MLU group. Even in languages like Hebrew or Turkish, in which the verbal inflections are either mandatory or more prominent, clear cut cases of real morphology use are not in the majority. Armon-Lotem (1997) reports that as many as 80% of the Hebrew verbs were inflected in an unclear or unclassifiable way. In Turkish, children may go through a stage of using nonsense inflections which preserve the prosody of the verb but which bear no apparent meaning (Aksu-Koç, 1988). The apparent distribution of morphology by lexical aspect may be a sampling error, resulting from the fact that it is based on a small fraction of children's utterances.

4.4.3. The problem of having no errors and speaker choice

If we were to take an utterance from any of the children in virtually any of these studies, we would find an inflected verb form that is perfectly grammatical in the adult

[44] The common absence of tense and grammatical aspect inflections is part of what has spawned the entire Optional Infinitive literature (e.g. Wexler, 1990)

language. Few of the individual forms that the children are producing are errors in and of themselves: there's nothing wrong, or even unusual, about saying *riding* or *broke*. The exceptions to this claim come from Italian, in which there are cases of children demonstrably using incorrect agreement and from Hebrew, in which there are examples of children over-generalizing a present tense prefix. By and large, though, the Aspect First hypothesis depends on an overall pattern of usage and not on errors of individual forms. However, grammatical aspect and to a lesser extent tense are semantic elements under a speaker's control. There is no rule in any language that says that one must periodically put a telic verb in the present tense. Common sense tells us that periodically situations will arise in which that will seem like the correct form to use, but maybe children don't agree. The distributional phenomenon may be telling us something about what children want to talk about and nothing at all about what their grammatical competence is.

4.4.4. The problem of parental input

In order for the Aspect First hypothesis to describe a meaningful stage of development, that stage should be distinct from the adult grammar. Some studies of parental input to children have shown that parent's speech to children shows a very similar distribution of inflections to the one the children are using. Using the same coding mechanisms that they used for the children, Shirai and Anderson (1995) for English and Stephany (1981) for Greek examined the speech the children's mothers. Both studies found the parental input showed the same trends found in the children's data: English speaking adults also tend to put telic verbs in the past tense and atelic verbs in the progressive and Greek speaking adults tend to combine imperfectivity with present tense and perfectivity with past tense. (Interestingly, it was only Greek parentese that showed the same distribution as the children; adult-to-adult speech did not show the same pattern.) Similarly, Naomi's parents showed the same pattern of "immediate" and "earlier" past tense uses as Naomi did

(Sachs 1979). Moreover, DiPaolo and Smith (1979) found 4-6 year old children maintaining the general trend though in a less extreme form than younger children and Li (1990) found 6 year old children maintaining the trend in an even stronger form. However, there is some disagreement on this point. Olsen et al. (1998) find that adult speech to the children in their study did not show the Aspect First distribution, primarily because adults put so may predicates of all types in the past tense. It is an open question, therefore, but the children's pattern of morphological use may (for at least some languages) be a reflection of the usage they are hearing.

4.5. An Alternative Measure: Comprehension

Although none of these problems prove that the production data is not in fact a good indicator of children's competence, they do indicate that we cannot treat such data as a transparant window into children's competence.

At the conceptual level, for example, there are many reasosn to be skeptical that children lack general time concepts. The developmental literature has investigated several facets to children's understanding of time (cf. Fraisse 1982), many of which children understand by the age of 2. For example, Pouthas (1993) reviews data showing that 8 month old infants can estimate durations with some accuracy; Bauer and Mandler (1989) show that 16 month olds can reproduce sequences, at least of causally related events; and Nelson (1986) aims to show that young children can succeed with temporal narrative structures if they are properly contextualized.

At the linguistic level, we know that children face a learning problem for temporal markers (no one is born knowing how to mark past tense) which opens up the possibility that children will make errors, moreover, the pervasiveness of the distributional pattern cross-linguistically makes the Aspect First hypothesis one that should be taken seriously. What is

needed is an alternative measure of children's competence, one that does not fall prey to the problems outlined above: namely, their comprehension.

Comprehension measures are on the whole more sensitive to children's knowledge than free production measures, and children generally pass comprehension tests before they can demonstrate equivalent competence in production (McDaniels et al 1996, Shipley et al. 1969). Presumably, the reason for this is that comprehension tasks remove many irrelevant elements that pose processing difficulties for the young child, such as planning the utterance and articulating it. We are concerned here about what concepts the child can entertain and what the child's underlying linguistic competence is, so the more sensitive the measure the better.

There have been only a few studies examining children's early comprehension of lexical and grammatical aspect. Li (1990) used a forced choice picture task to test the comprehension of grammatical aspect in children (aged 4 to 6) acquiring Mandarin Chinese[45]. He did find a pattern highly consistent with the Aspect First hypothesis (children demonstrated better comprehension of telic predicates with perfective marking than with imperfective marking and of atelic predicates with imperfective marking than with perfective marking) but his results are difficult to interpret because of the high error rate overall and the absence of relevant statistical tests. For example, six year old children still apparently performed at chance when asked to pick out the picture that showed an atelic predicate in the perfective aspect. The persistence of such errors in such old children recalls Li's production data results and suggests even more strongly that in adult Mandarin not all combinations of grammatical aspect with lexical aspect types are in fact grammatical. Mandarin is therefore not an ideal language in which to evaluate the Aspect First hypothesis

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Li's procedure was essentially the same as that used by Weist in his studies. A detailed description will be provided in §5.5.2.

as children's compliance with it cannot be distinguished from their compliance with the adult language.

Behrend (1990) and Behrend, Harris and Cartwright (1995) have conducted a series of experiments looking at how children (aged 3 and 5) use grammatical aspect markers for learning the names of novel actions. They showed children video-tapes of unusual telic events consisting of a characteristic action and an end-point (such as twirling a spaghetti server to collect a bunch of tangled yarn lying on a table) and describe the actions using either no grammatical aspect marking ("She will pint"), present imperfective marking ("She is pinting") or past perfective marking ("She pinted"). The children then saw a revised version of the event with some dimension of it changed: crucially either the end-point was different (the yarn stayed dangling instead of being collected) or the action was different (scooping instead of twirling). Children's hypothesized meaning for the new verb can be determined by which revisions to the event children reject. The rejection of the revised end-point indicates that they considered the nature of the end-point to be part of the verb's meaning while acceptance of the revised end-point indicates that they did not (and similarly for the revised action). Since the verbs themselves were nonsense verbs, the question was whether the grammatical aspect used in the initial presentation would influence what parts of the event were treated by the children as part of the event. This work can be viewed as an implicit comprehension test: if children believe that perfective aspect (or past tense) means telicity, they should consider the nature of the end-point presented as crucially part of the meaning of verbs presented in the past perfective form; and, if children believe that imperfective aspect (or present tense) means atelicity, a change in the end-point for verbs presented in the present imperfective should be irrelevent. The results from the three year olds were consistent with the Aspect First hypothesis: they resisted changes in end-point more often when the verb had been presented in the past perfective and resisted changes in action more often when the verb had been presented in the present imperfective. Five year olds showed a different pattern, resisting changes to the event's end-point regardless of the form in which

the verb had been presented. These data are suggestive, but they are far from conclusive. These experiments were not designed to test what the children actually though the tense and grammatical aspect morphology meant, only whether they would use it as a cue to the verb's meaning. Since a correlation does exist in parents' speech between lexical aspect type and grammatical aspect/tense type (though it is of uncertain strength), children might use tense or grammatical aspect markers as a cue for learning new words even while not actually mistaking their meanings. The different performance by the five year olds may simply reflect the greater number of cues they have at their disposal for learning new words.

Van Hout (1998) has examined children's (aged 3 through 5) and adults' comprehension of the compositionality of lexical aspect in English and Dutch. She told her subjects stories involving the verbs *eat* and *drink*, which may be either telic or atelic, depending on the presence or absence of a direct object and the quantificational properties of that object. She crucially compared subjects' interpretations of four types of sentences such as the following:

(135)	Who drank?	(atelic)
(136)	Who drank water?	(atelic)
(137)	Who drank his water?	(telic)
(138)	Who drank up his water?	(telic)

She found that the 3 year olds interpreted sentence types (135), (136), and (137) as atelic, despite the fact that sentence (137) qualifies as telic for adults[46]. Only sentence type (138), which includes an extra marker of telicity in the particle *up*, was restricted to telic interpretations by all the children. Van Hout argues that the youngest children had not yet mastered the full linguistic encoding of telicity and that they identify telicity only when it is marked by an element (such as the particle) which is explicitly devoted to expressing it. That is, the youngest children understand the concept of telicity (they do distinguish between

[46] Actually, one of Van Hout's interesting results is that adult English speakers are themselves ambivalent about the telicity of sentences like (137) despite the fact that these sentences are uniformly treated as telic in the linguistics literature. Adult Dutch speakers do treat (137) as telic, however, although Dutch children do not.

sentence types (135) and (138)) but they face difficulties in mapping that concept fully onto the proper linguistic parts and initially under-map the concept.

This data potentially provides support for the Aspect First hypothesis: if children by the age of 3 prefer to map telicity to an independent morphological marker (the particle), might they not have found other morphological markers (such as the progressive *-ing* or the past tense *-ed*) and tried to map lexical aspect properties onto those? The experiments in the following chapter will investigate whether grammatical aspect and tense show a similar pattern in development as van Hout finds for telicity (i.e., early competence with the concepts but difficulties in linguistic mapping) or whether children initially mis-use grammatical aspect and tense markers as markers of lexical aspect.

The comprehension work that is most relevant to the following studies has been done by Weist and his colleagues (Weist 1983, Weist 1991, Weist et al. 1991, Weist et al. 1997). The portion of this work that relates to grammatical aspect and tense is very similar to the experiments described in the following chapter and will be discussed at length in §5.5.2.

4.6. Chapter Summary

This chapter has reviewed studies looking at children's production data from a variety of languages with respect to the Aspect First hypothesis which states that children initially use tense and grammatical aspect morphology to mark the lexical aspectual property of (a)telicity. I have argued that the production data, insofar as it can, supports the Aspect First hypothesis. I have further argued that the production data can't take us far enough, and that we cannot interpret this phenomenon (does it reflect a conceptual lack, a linguistic mapping problem, or nothing in particular) without using more sensitive measures of children's competence, such as their comprehension of the relevant forms.

Chapter 5. Comprehension Studies

As discussed in the previous chapter, a necessary pre-condition for the Aspect First hypothesis is that children are not initially using tense and grammatical aspect morphology to mark what adults use it for (namely, tense and grammatical aspect). The experiments presented in this chapter are designed primarily to test that pre-condition: experiment 1 asks if children understand grammatical aspect as adults do in the context of the imperfective paradox, and experiment 2 asks if children understand tense as adults do. A secondary question in these experiments is aimed specifically at the conceptual development account of the Aspect First hypothesis: do children understand the concepts encoded by tense and grammatical aspect even when (or if) they do not know which morphemes those concepts are encoded by? Open class cues will serve as conceptual controls to the straight morpho-syntactic task trials. These experiments test children who are approximately the same age as those children who manifest the Aspect First distribution of forms in their production as discussed in Chapter 4 (i.e., the young groups have mean ages around 2.7) as well as children who are older, thus allowing us to see a developmental trend in knowledge of grammatical aspect and tense, if one exists.

5.1. Open Class Cues as Conceptual Controls

One of the hypotheses discussed in the previous chapter is that children's initial distribution of morphology is driven by a conceptual deficiency: the children do not have the concepts encoded by tense (or grammatical aspect) and cannot therefore use the morphology to encode the concepts they do not have. Both of the experiments reported below attempt to address this issue by running conceptual controls. These controls consist of sentences

which convey the concepts of tense and grammatical aspect using open class elements in addition to (and in one case, instead of) closed class elements.

Open class items are what we normally think of as content words (e.g. *ball*, *tree*, *Mommy*) and the class is open in the sense that it is easy to add new items to it (in recent memory, e.g. *fax*, *teflon*, *grep*). Closed class items (e.g. articles, inflections and auxiliaries) form a small set that only rarely gets new members. The two classes generally pattern separately in a variety of domains: phonologically, open class items often receive stress while closed class items are usually stressless or get reduced via contraction; lexically, open class items are often free morphemes while closed class items are often bound morphemes; syntactically, closed class elements are usually associated with functional heads while open class elements have more varied distribution; semantically, open class items cover an enormous range while closed class items are severely restricted (cf. Talmy 1988 for an extended discussion of the semantic restrictions of closed class items).

The psychological literature has demonstrated the differences between open and closed class elements in a variety of domains: they lead to different potentials in ERP scans of the brain (van Petten and Kutas 1991), they show different patterns of loss in aphasic patients (Bradley et al. 1980; but see also Gordon and Caramazza 1982), and most importantly for the current purposes, they are learned at different times and in different ways. Open class items begin to be used around the age of one and constitute virtually all of a child's first 50 or so words (Clark 1993). Words from this set are acquired throughout a person's lifetime. Closed class items do not begin to be used productively until about the age of 2, although virtually the entire set has been learned by the time the child enters school (Brown 1973). Moreover, although even young children (18-33 months old) balk if presented sentences that do not contain any closed class elements (Shipley et al. 1969), children at this age are themselves more likely to omit closed class than open class elements from their own utterances, leading to the so-called telegraphic style of speech (Shipley et al. 1969, Brown 1973).

Given these qualitative differences between open and closed class elements, and in particular the fact that open class elements are learned first, there is good reason to expect children to map their concepts onto the open class before the closed class domain, thus making the open class controls a more sensitive measure of the children's conceptual abilities.

5.2. Experiment 1: Grammatical Aspect

The test of grammatical aspect used in this experiment exploits the fact that telic predicates have different entailments in the perfective and imperfective aspect (cf. §2.2.2). Recall that a telic predicate like *build their winter quarters* entails that the event is completed when it appears with perfective grammatical aspect (139b) but has no such completion entailment when it appears with imperfective grammatical aspect (139a). This difference is shown clearly when the continuation in (139d) is added: the continuation is fine after the imperfective version (139a) but sounds odd after the perfective version (139b).

(139) a. The Ringling Brothers were building their winter quarters in Baraboo
b. The Ringling Brothers built their winter quarters in Baraboo
d. ... but they never finished them and moved to Florida instead.

The task used here presents the child with a completed and a half completed version of the same telic event, for example, a half filled in puzzle and a completely filled in puzzle. It then asks the child to match these events to a description of the event in either imperfective or perfective grammatical aspect, for example, *I was filling in the puzzle* and *I filled in the puzzle*. In order to successfully match both sentences, the perfective sentence (*I filled in the puzzle*) must be matched to the completed event and the imperfective sentence (*I was filling in the puzzle*) must be matched to the incomplete event. From a truth-conditional perspective, the imperfective sentence may apply to either version of the event (the imperfective lacks a completion entailment; it does not entail the lack of completion) so

there is a problem-solving dimension to this task. The fact that the children are presented with both perfective and imperfective sentences combined with the fact that the perfective sentence must be matched to the completed version of the event to satisfy its truth conditions should lead the child to match the imperfective sentence with the incomplete event. Success on this task, therefore, requires the children to reason about the sentences as pairs and there is a risk that this introduces a problem-solving component which might mask their competence with grammatical aspect. To help assess the possibility that children's behavior might be based on their evaluation of only a single sentence (in which case, the correct answer for the imperfective case is up for grabs), an adult control study was run in which adults were asked to match a single sentence (either perfective or imperfective) to the scene it best described (completed and incomplete). All the sentences in this experiment are in the past tense, so only the semantics of grammatical aspect are being tested here.

Subjects perform the task in two ways: once with only the closed class morphology of grammatical aspect to guide them and once with open class cues that contribute roughly the same semantic information as the grammatical aspect morphology. The open class cues condition serves as a conceptual control and provides the children with the opportunity to demonstrate that they have the concepts encoded by the grammatical aspect morphology, even if they don't have those concepts actually assigned to the right morphology.

5.2.1. Methods

5.2.1.1. Subjects

Subjects were children attending Philadelphia day cares whose parents gave permission for them to be tested. Subjects were rejected if they (1) failed the pre-test or (2) refused to cooperate on so many trials that they didn't complete one full counterbalanced set of stimuli. According to parental report, all subjects had English as their primary language.

Three groups of subjects were tested. The young group consisted of 27 subjects (not counting 12 who were rejected for one of the reasons just noted) with a mean age of 2.7 years (ranging in age from 1.89 to 3.17 years). The middle group consisted of 20 subjects (not counting 6 who were rejected) with a mean age of 3.9 years (ranging from 3.29 to 4.46 years). The old group consisted of 12 subjects (no old subjects had to be rejected) with a mean age of 5.0 years (ranging from 4.48 to 5.56 years).

In addition, 16 college age students participated in the adult control study. They received course credit for their participation.

5.2.1.2. Stimuli

Four different telic events were used. Each event was presented in two versions, a complete version and a half complete version. The ROLL A CAR TO SCHOOL event consisted of a small toy school-house and two toy cars which were rolled across the floor and into the school-house. The complete version had the car inside the school and the half complete version had the car about a foot away from the school. The FILL IN A PUZZLE event consisted of two wooden puzzles that had cut-out slots for four pieces each; the slots had pictures in them that corresponded to the pictures on the pieces. The complete version had all four pieces in their slots and the half-complete version had two pieces in their slots and two pieces propped up against the puzzle. The EMPTY OUT A CUP event consisted of two plastic cups filled with a half-dozen wooden blocks each. The complete version had the cup empty of blocks and the half-complete version had the cup still containing two blocks. The DRAW A FACE event consisted of two crayon drawings. The complete version showed a face and the half-complete version showed a circle with one eye and one ear.

To be matched with each set of events was a pair of sentences. For the closed class condition, the perfective sentence was in the simple past tense and the imperfective sentence was in the past progressive. As discussed above, the perfective sentence must be matched to

the completed event and the imperfective sentence is therefore left to the incomplete event. For expository convenience, I will term the open class cue that is properly matched to the complete event as perfective and the open class cue that is properly matched to the incomplete event as imperfective. The open class versions added two components to their closed class counterparts: first, they included a phrase of the form, *I'm partly/all done* and second, they included another adverbial (*in the middle of* or *completely*). The open class version of the perfective version contains within it a perfective, closed class sentence. The open class version of the imperfective version does not quite contain within it an imperfective closed class sentence, though it does contain the verb in the *-ing* form as it is in the imperfective version. Notice in addition that there is no ambiguity about where to apply the imperfective open class sentence: it describes only the incomplete event. The full set of sentences used is shown in Table 3.

Table 3: Stimuli for the Grammatical Aspect Task

Event	Condition	Closed class Cue	Open Class Cue
Car to School	imperfective	I was rolling my car to school	I'm partly done. I'm in the middle of rolling my car to school
	perfective	I rolled my car to school	I'm all done. I rolled my car to school completely.
Fill in Puzzle	imperfective	I was filling in my puzzle	I'm partly done. I'm in the middle of filling in my puzzle
	perfective	I filled in my puzzle	I'm all done. I filled in my puzzle completely.
Empty Cup	imperfective	I was emptying out my cup	I'm partly done. I'm in the middle of emptying out my cup
	perfective	I emptied out my cup	I'm all done. I emptied out my cup completely.
Draw a Face	imperfective	I was drawing my face	I'm partly done. I'm in the middle of drawing my face
	perfective	I drew my face	I'm all done. I drew my face completely.

5.2.1.3. Procedures

The subject was first introduced to two characters, either a bunny and an elephant or a dog and a duck. One of the two characters was portrayed consistently with a high, squeaky voice and the other with a low (somewhat silly) voice. Subjects were told that the characters were very shy and that when they did things, they didn't like to be watched. A screen covered with colorful stickers was placed between the child and the characters while the events were being set in place and the child's attention was directed to the screen. This forced the child to use what the characters said to determine which event-version belonged to which character.

At the beginning of each trial, the child was presented with the toys for the event and encouraged to perform the test event themselves. Then the screen was brought out and the characters, hidden from the child, engaged in the event. Up to this point in the trial, the event would be described only in the infinitive form, in phrases such as *Will you show me how to VP* or *The animals want to VP*. When the events were ready, the screen was removed

revealing two versions of the test event, one completed and one only half completed. The child was told that now the characters would say whose puzzle/cup/picture/car was whose. The characters came forward one at a time to a neutral place above the events and uttered the test sentences; one uttered an imperfective sentence and the other a perfective sentence. Each sentence was repeated at least twice and the children were encouraged to repeat the sentences. The first sentence presented always corresponded to the first sentence the child would have to match and that sentence was also repeated immediately before the child engaged in the match. In order to match, the child was handed one of the characters, who repeated his sentence, and told to put it on top of/next to his X. The child was then asked to place the second character on top of/next to his X. The experimenter marked down which event version the subject chose for the first character and the subjects were uniformly praised for their performance. Only the placement of the first character is of interest because this is a forced choice task and the placement of the first character determines the placement of the second character. This leads to the following terminological convention in describing the experiment: the imperfective conditions refer to those trials in which the imperfective sentence is to be matched first and the perfective conditions refer to those trials in which the perfective sentence is to be matched first.

The pre-test followed exactly the same procedure but used irrelevant test events. The pre-test had two trials: one used plastic grapes and plastic bananas and when the screen was removed, the characters told the child which one they liked; the second used a toy crib and a toy rug and when the screen was removed, the characters told the child which one they sat on.

5.2.1.4. Design

The experiment has a 2 (cue type: open or closed) X 2 (condition: imperfective or perfective) design creating 4 different cells. Pilot testing suggested that different events may affect the responses differently so event type was controlled (roll a car to school, draw a face, empty out a cup, fill in a puzzle) but was not considered as a factor in the design. All the events are telic so differences among them is not what this experiment is expressly interested in.

Subjects received 8 trials (consisting of two trials of each design cell) spread over two testing sessions containing 4 trials each. Before the first session, subjects received 2 trials of the pre-test and before the second session, they repeated one of the pre-test trials. In each session, subjects heard two trials in the closed class only condition (one test trial in the imperfective and one in the perfective) and two trials in the open class cues condition (one test trial in the imperfective and one in the perfective). Each trial was conducted with a different toy and each toy received a different combination of conditions across trials. To alleviate possible interference effects from one session to another, a different pair of stuffed animals was used in each session. The order of toy used, first stuffed animal placed and trial type was counter-balanced across subjects with the constraint that trials with the same cue-type were kept together (a subject would here either two open class trials followed by two closed class trials or vice versa).

The dependent variable was the event version (complete or incomplete) where the child matched the first of the pair of sentences.

5.2.1.5. Adult Control Procedure and Design

Adult subjects were tested using the same events (roll a car to school, draw a face, empty out a cup, fill in a puzzle) but without the subterfuge of the shy animals. In addition, two atelic events (rest and scribble) were used as distracter events. Adults were presented with

two versions of each event, with the different versions labeled as either “A” or “B”. Subjects were presented with booklets containing the test sentences (the sentences for each event were placed on a separate page) and told to match the sentences to the event versions by marking an A or a B by the sentence. Adult subjects were tested in two parts. In the first part, they were given six trials (four telic events plus two atelic distracters) of a single sentence and told to match it to whichever version (A or B) the sentence best described; half the sentences were perfective and half were imperfective. In the second part, subjects were given three trials (two telic events plus one atelic distracter) equivalent to the child’s task: subjects received both the perfective and the imperfective descriptions and asked to indicate how they matched to the event versions marked A and B. Adults were only tested using closed class cues.

5.2.2. Results

Chance performance was set at .50, as the choice was always between two options. A table of the mean correct across subjects in each group for each cell in the design is shown in Table 4. The young and middle groups behaved equivalently: they performed at chance levels given closed class cues (both imperfective and perfective conditions) and also given open class cues indicating the imperfective; they performed better than chance only given open class cues indicating the perfective condition. The old group performed above chance given open class cues (both imperfective and perfective conditions) but given closed class cues, rose above chance only on the perfective condition.

Table 4: Mean Percentage Correct for Grammatical Aspect Task

	Open		Closed	
	imperfective	perfective	imperfective	perfective
young n = 27 m age = 2.7	.51	.71*	.51	.52
middle n = 20 m age = 3.9	.60	.70*	.39	.53
old n = 12 m age = 5.0	.91**	.96**	.52	.96**

* $p < .01$, ** $p < .001$ Compared to chance = .50

A mixed design ANOVA was run with age group (young, middle and old) as a between subjects factor and condition (perfective and imperfective) and cue (open and closed) as within subjects factors. There was a significant effect for age group ($F (2, 56) = 11.42$, $p < .0001$) with the old group performing better than both the middle group ($t (31) = 2.12$, $p < .05$) and the young group ($t (48) = 2.12$, $p < .05$) although there was no difference between the latter two groups ($t (46) = 1.87$, n.s.). Main effects were also found for condition and cue, with subjects performing better in the perfective conditions than the imperfective conditions ($F (1, 380) = 11.65$, $p < .001$) and better given open class cues than closed class cues ($F (1, 380) = 12.52$, $p < .001$). The only interaction which was significant was the three-way interaction ($F (2, 380) = 3.3$, $p < .05$), which was driven by the fact that the old group scored so low in the imperfective condition given only closed class cues.

There were no item effects for the different events, although there were some locally significant differences among events in certain conditions. The young group showed some event effects given only closed class cues. In the closed class imperfective condition, the EMPTY OUT A CUP (mean correct = .23) event was significantly worse than the ROLL A CAR TO SCHOOL event (mean correct = .75, $t (24) = 2.13$, $p < .05$) and the FILL IN A PUZZLE event (mean correct = .62, $t (24) = 2.01$, $p < .05$). In the perfective condition, the ROLL A CAR TO SCHOOL event (mean correct = .31) was significantly worse than the EMPTY OUT A CUP event

(mean correct = .77, t (24) = 2.07, p < .05). The only other item effect came from the old group in the closed class imperfective cell: the ROLL A CAR TO SCHOOL event (mean correct = .17) was significantly worse than the FILL IN A PUZZLE event (mean correct = .83, t (9) = 2.18, p < .05).

The adult results showed an interesting split. When adults were presented with essentially the same task as the children (i.e., when they matched two sentences using closed class cues only to the two event versions) they performed well above chance (mean correct = .87; t (15) = 6.06, p < .0001), thus demonstrating full knowledge of both grammatical aspect as well as the problem solving skills necessary for the task. However, when adults were asked to match only a single sentence, their performance looks much like that of the oldest child group. As can be seen in Table 5, adults successfully matched perfective sentences presented in isolation to the completed version of the event but were at chance when matching the imperfective sentences presented in isolation to the incomplete version of the event. Both the old children and the adults showed a significant difference between their performance on perfective and imperfective sentences given closed class cues (old children, t (11) = 2.21, p < .05; adults, t (15) = 2.23, p < .05); such a difference was not found for the middle or young children (t (19) = 1.9, n.s. and t (26) = 1.8, n.s., respectively).

Table 5 Mean Percentage Correct for Grammatical Aspect Task, Adults and Oldest Child Group

		Closed	
		imperfective	perfective
old n = 12 m age = 5.0	matching two sentences	.52	.96**
Adults n = 16 m age > 18.0	matching single sentences	.47	.91**

** p < .001 Compared to chance = .50

5.2.3. Discussion

These results show a developmental trend in the comprehension of grammatical aspect. Children in the young and middle groups do not succeed with the closed class cues at all and can use only the perfective open class cues reliably. The old group of children succeeded with the open class cues and the perfective closed class cues, but still showed chance performance in the imperfective closed class case. This pattern of results on the closed class cues condition, however, mirrored the performance of adults tested using individual sentences (instead of the pairs of sentences used by the children).

These results are somewhat at odds with previous research. Wagner (1997) found that children with a mean age of 2.7 (equivalent to the young group here) were able to succeed in this task given open class cues in both the perfective and the imperfective conditions. There may, however, be a simple explanation for the different results here. Wagner (1997) did not control the number or variety of open class cues used and subjects in that experiment received as many as five open class cues in the imperfective case and as many as eight cues in the perfective case. The current study controlled this element and restricted the number of cues to two per condition and used the same two cues in all open class trials. In choosing the open class cues for this study, I attempted to use the most informative cues from Wagner (1997); the choices were successful in the perfective case but apparently were not in the imperfective case. It is unclear whether children succeeded with the imperfective open class cues in the previous experiment because of some particular cue not used here or simply because of the sheer number of cues used. This is a question that will have to be taken up in further research.

The results here are also at odds with previous work (Wagner 1997 as well as Weist 1991, Weist 1983 and Weist et al. 1998) in terms of the time course of development of comprehension of grammatical aspect as coded by the closed class elements. Wagner (1997) found that children with a mean age of 3.8 (equivalent to the middle group here) were able to

succeed with the closed class cues in both the perfective and imperfective conditions (Weist has found children as young as 2.5 succeeding in these conditions, but see §5.5.2 for discussion). However, in this case, the current results are more convincing. The problem solving dimension of the task used in this experiment (as well as in Weist's work) raises some problematic issues. Most notably, it raises the possibility that children don't need to understand both perfectivity and imperfectivity to solve the task: as long as children have learned one of the two, they can derive the correct choice for the other. In fact, the task itself is structured similarly to fast-mapping tasks which are aimed at showing children can learn new words in some circumstances after hearing them only once. In a classic task (Carey and Bartlett 1978), children were asked to bring the experimenter a chromium tray (*chromium* being the novel word) and children's success depended on the presence of a contrast term in the instructions: *Bring me the chromium tray, not the green one, the chromium one*. Because the children knew what *green* meant, they could deduce that the chromium tray was the not-green tray and thereby succeed. Similarly, in this grammatical aspect task, a child who knew only the perfective could successfully deduce the right answer for the imperfective as being the event that shouldn't go with the perfective. Interpreting success on this task has always relied on the hope that children's performance was being informed by their knowledge of grammatical aspect (both perfective and imperfective) and not simply on problem solving skills like those used in a fast-mapping task.

The performance of the oldest child group is therefore quite satisfying in that it suggests that the problem solving component may be precisely where the children are having difficulties[47]. These children were at ceiling with the closed class perfective sentences but at chance with the closed class imperfective sentences. Clearly these children were not able to use their knowledge of perfective grammatical aspect to deduce the proper location for the

[47] Anecdotally, it was clear that at least some of the 5 year olds appreciated the problem solving dimensions of the task in addition to understanding grammatical aspect. One such subject would reason aloud before placing the animals, saying things like: *this one (the imperfective sentence) could go on*

imperfective sentence and this suggests that, despite the fact that the children heard both sentences before they matched either of them, their matching behavior was guided principally by the particular sentence they matched first[48]. If the children are approaching this task on a sentence by sentence basis, our expectations for their performance on the perfective and imperfective sentences differ: there is a truth-conditionally right answer for the closed class perfective sentences (as well as for both open class cue sentences) but either event is a right answer for the closed class imperfective sentence. These semantic differences lead us to expect 100% performance for the perfective sentences (where the right answer is unequivocal) and 50% performance for the imperfective sentences (where the right answer is equivocal) even for subjects who fully comprehend grammatical aspect. When adults (who we presume do have full comprehension of grammatical aspect) are asked to perform this task one sentence at a time that is in fact how they perform. Thus, the pattern of results found for the oldest children does in fact demonstrate full knowledge of both perfective and imperfective aspect.

Notice that what is important for this interpretation is that the closed class imperfective sentences can in principle be matched to either event, and what constitutes the right answer for these sentences should be established by adult performance in that condition. For the closed class perfective sentences and all of the open class cue sentences on the other hand, there is a clear right answer so chance performance in these cells, as shown by subjects in the younger age groups, cannot be interpreted as positive knowledge.

How does this experiment bear on the Aspect First hypothesis? One particular explanation of the hypothesis tested here was whether children understand the concepts behind grammatical aspect even if they do not understand the closed class morphology. The

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either, but that one (the perfective sentence) has to go here (completed event) so this one must go here (incomplete event).

[48] As noted above, placement of the first animal virtually always determined placement of the second. Even when an incorrect first match forced the child to match the second sentence to an event in a way they must have known was wrong, the children never switched their original match and only very rarely looked uncomfortable at having to make a bad match.

results on this front are inconclusive as only the oldest child group passed both the perfective and imperfective conditions with the open class cues. However, all the children passed the open class cue perfective condition, thus demonstrating competence with the concept of completion at least from the age of 2.7. As noted above, it is unclear how seriously to take the failure with the imperfective open class cues since these cues may have been inopportunely chosen. In any event, failure with the open class cues does not translate directly into failure at the conceptual level as success in this task still requires the mediation of those concepts by some linguistic units. With respect to the younger groups' chance performance with the closed class cues, we face the standard difficulties of interpreting null results. The most that can be claimed is that these children do not understand grammatical aspect morphology in the way adults do. The experiment was only designed to test for the adult mappings, and thus leaves open the question of whether the younger children are using some other kind of mapping that was not directly tested. Certainly these results are at least compatible with the Aspect First hypothesis for the younger children.

5.3. Experiment 2: Tense

This experiment examines children's comprehension of tense. Its primary aim is to test past and present tense (which are the forms involved in the Aspect First hypothesis) but future tense was looked at as well, for completeness sake. Since the goal in this experiment is to test tense, grammatical aspect information is held constant: both past and present tense sentences are in the imperfective (progressive) form. In addition, lexical aspect is explicitly manipulated to permit a more complete examination of the Aspect First hypothesis.

The form of the task involves a stuffed kitty cat who walks down a road performing the same event at the beginning, middle and end of the road. While the kitty is in the midst of performing the event for the second time (at the mid-point of the road), the child is asked about the event in the past, present, or future. As the kitty goes down the road from event

to event, he leaves a trail of inky footsteps (thanks to a rubber stamp attached to his bottom) which allow the child to trace the path of the kitty and provide a constant cue to the temporal ordering of the events[49].

The criteria for getting a correct answer are extremely strict in this experiment: the second, ongoing location is the only correct answer for the present tense questions, the initial location is the only correct answer for the past tense questions and the final location is the only correct answer for the future tense questions. Given the pragmatics of the task, in which the only varying piece of information is tense, this scoring is sensible. However, the ongoing location satisfies the basic semantic requirements of all the past and future tense test questions as well as the present tense ones.

As we saw in the previous experiment, telic predicates in the past imperfective (all the past tense sentences in this experiment are in the past imperfective form) are semantically acceptable with incomplete events; they are therefore a possible description of the ongoing event[50]. This part of the problem might have been avoided by using past perfective (i.e., simple past tense) instead of past imperfective forms. The reason that this was not done was because this experiment was intended to complement -- not duplicate -- the previous experiment of grammatical aspect. The present tense in English, on a non-habitual reading, requires the imperfective form. If the present imperfective were contrasted with a past perfective form, then tense and grammatical aspect would be confounded in this experiment and the results would be uninterpretable with respect to tense alone. The atelic events pose an even more extreme design problem in the past tense because one of the

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[49] The trail, combined with the directionality of the road, may be the key element to this task's success. Extensive piloting showed that when even relatively old children (age 4) were asked to identify two completely random events based on tense information they were quite bad at it. The developmental literature (e.g. Bauer and Mandler 1989) has suggested that causal links between events help children order them temporally. The inky footsteps allow this experiment to have the advantage of a causal link (the kitty's path) without reducing the task to a test of the causal relationship of events.

[50] In fact, the two experiments combined ask the children to show comprehension of a complete range of interpretations for the past imperfective forms with telic events. In experiment 1, the past imperfective form is applied to incomplete telic events (where it is contrasted with the past perfective) while in experiment 2,

entailments of atelicity is that as soon as you can say that an atelic event is happening, you can also say that it has happened. Since the query is given after the ongoing event has begun, a past tense description (of either grammatical aspect type) is always a possible description.

The future tense sentences can also apply to the ongoing event because at the time of the query, the event is continuing and will continue for at least a few seconds into the future. Applying the future tense to the ongoing situation is even somewhat felicitous with the telic events since these events haven't yet reached their completion point at the time of the query. If the query is interpreted as asking about the timing of the completion of the event, it is quite sensible to match it to the ongoing situation.

The task as it stands requires the children to understand not only the semantics of tense, but the pragmatics of tense as it is used in this task. This is a tall order, but, as we shall see, turns out to be one that even the youngest children are capable of to some degree. As with the previous experiment, subjects will perform the task in two ways: once with only the closed class morphology of tense to guide them and once with open class cues that contribute roughly the same semantic information as the tense morphology. The open class cues condition serves as a conceptual control and provides the children with the opportunity to demonstrate that they have the concepts encoded by the tense morphology, even if they haven't yet assigned those concepts correctly.

5.3.1. Methods

5.3.1.1. Subjects

Subjects were children attending Philadelphia day cares whose parents gave permission for them to be tested. Subjects were rejected if they (1) failed the pre-test or (2) refused to cooperate on so many trials that they didn't complete one full set of trials counterbalanced

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the past imperfective form is applied to complete telic events (where it is contrasted with the present

for tense and cue type. According to parental report, all subjects were acquiring English as a primary language.

Two groups of subjects were tested. The young group consisted of 25 subjects (not counting 10 who were rejected for one of the reasons noted above) with a mean age of 2.74 years (ranging from 1.89 to 3.17 years). The old group consisted of 21 subjects (not counting 7 who were rejected for one of the reasons noted above) with a mean age of 3.85 (ranging from 3.29 to 4.46 years). Note that the older group here is equivalent in age to the middle group from the grammatical aspect experiment.

5.3.1.2. Stimuli

Six different events were used, three of which were telic and three of which were atelic. All were acted out by a small stuffed animal kitty. It is helpful to think of each event as having three phases which correspond to their description in the past, present and future. During each trial, the subject would see each event in each of its three phases placed at different locations along a paper road. The present tense phase was always where the kitty was currently engaged in performing the action; for telic events, that means the event was only partially complete. The past tense phase was where the kitty had finished with the event; for telic events that means that the event was always completed. The future tense phase was where the kitty had not yet gotten to the toy to perform the event.

The telic events were FILL IN A PUZZLE, EMPTY OUT A CUP, and DRAW A FACE. The FILL IN A PUZZLE events consisted of three one-piece puzzles in which a foam shape (a triangle, circle, or square) fit inside a matching frame. The EMPTY OUT A CUP events consisted of three plastic cups, each containing a half-dozen wooden blocks. The DRAW A FACE events consisted of crayon drawings of a face. Before this trial began, a crayon X was drawn at three locations on the road and the child was told that these were the places where

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imperfective).

the kitty wanted to draw a face. Thus the future phase for this event was indicated by an X with no face drawing next to it. The atelic events were REST, HOP AROUND, and PLAY WITH A FRIEND. The REST events consisted of three places the kitty could rest: a toy crib, a rug, and a toy bed. Each resting spot was approximately the same size. The HOP AROUND events consisted of the kitty jumping up and down repeatedly in the same spot and thereby leaving a messy splotch of inky footprints. As with the DRAW A FACE events, before the hopping events began, a crayon X was drawn at three locations on the road and the child was told that these were the places that the kitty wanted to hop around. The PLAY WITH A FRIEND events consisted of three small wooden animals (a horse, a camel and a moose) which the child was told were friends of the kitty. Playing with them consisted of the kitty picking up each friend and dancing around in the air.

A different sentence was matched to each set of events. The past and present tense sentences were both in the progressive form so that, as noted above, the grammatical aspect component of the task was held constant. The future forms used the auxiliary *gonna* which is common in child language. The open class versions of the sentences all consisted of the parallel closed class version of the sentence with the addition of appropriate time adverbials. Two adverbial expressions were used for each of the past and future sentences (*before* and *already* for the past and *next* and *in a second* for the future); the adverbial *right now* was used for the present tense sentences. The full set of sentences used is shown in Table 6.

Table 6 Stimuli for the Tense Experiment

Event	Tense	Closed class Cue	Open class Cue
Telic			
Fill in Puzzle	past	Where was he filling in a puzzle	Where was he filling in a puzzle before/already
	present	Where is he filling in a puzzle	Where is he filling in a puzzle right now
	future	Where's he gonna fill in a puzzle	Where's he gonna fill in a puzzle next/in a second
Empty out Cup	past	Where was he emptying out a cup	Where was he emptying out a cup before/already
	present	Where is he emptying out a cup	Where is he emptying out a cup right now
	future	Where's he gonna empty out a cup	Where's he gonna empty out a cup next/in a second
Draw a Face	past	Where was he drawing a face	Where was he drawing a face before/already
	present	Where is he drawing a face	Where is he drawing a face right now
	future	Where's he gonna draw a face	Where's he gonna draw a face next/in a second
Atelic			
Rest	past	Where was he resting	Where was he resting before/already
	present	Where is he resting	Where is he resting right now
	future	Where's he gonna rest	Where's he gonna rest next/in a second
Hop Around	past	Where was he hopping around	Where was he hopping around before/already
	present	Where is he hopping around	Where is he hopping around right now
	future	Where's he gonna hop around	Where's he gonna hop around next/in a second
Play with Friend	past	Where was he playing with a friend	Where was he playing with a friend before/already
	present	Where is he playing with a friend	Where is he playing with a friend right now
	future	Where's he gonna play with a friend	Where's he gonna play with a friend next/in a second

5.3.1.3. Procedure

Before the trials began, (as well as periodically between trials) the children were shown a paper road and asked to drive a toy car down the road. They were then introduced

to the kitty with a footprint stamp attached to his bottom and shown how the kitty left inky footsteps behind him as he went down the road. Before each event containing toys, the child was given the opportunity to play with, or at least handle, the relevant toys. For each event, a toy needed for that event (or simply an X mark for the drawing and hopping events) was placed at the beginning, middle and endpoints of the road. The kitty performed the event at the beginning of the road, and then hopped down the road to the middle of the road (leaving behind inky footsteps) and the next toy. Before the kitty engaged each event, the event was described for the child in the infinitive form using the carrier phrase: *The kitty wants to VP*. As the kitty was engaged in performing the event a second time, the test question was asked. The subjects were allowed to answer the question orally (this was more common among the older children) or by pointing to the road. Children who were vague about their pointing were told to answer by touching either the paper road or the toy. The experimenter marked down which event phase the subject chose and the subjects were uniformly praised for their performance.

The pre-test for this task simply required the child to drive the toy car on the road (to demonstrate that they knew the road had some directionality) and to point to different places on the road (to demonstrate that they could and would point). Children were only pre-tested before the first block of trials.

5.3.1.4. Design

The experiment has a 2 (cue type: open or closed) X 3 (condition: past, present or future) X 2 (event type: telic or atelic) design creating 12 different cells. As with the previous experiment, differences between the particular events (telic: fill in a puzzle, empty out a cup, draw a face; atelic: rest, hop around, play with a friend) were not of interest and so were controlled but were not included in the design.

Subjects received 12 trials (corresponding to the 12 cells) spread over two testing sessions containing 6 trials each. In each session, subjects heard three trials in the closed class only condition (one test trial each in the past, present and future) and three trials in the open class cues condition (one test trial each in the past, present and future). Event type (telic or atelic) was spread evenly over the different tense conditions and cue conditions within each session. Each trial was conducted with a different toy and each toy received a different combination of conditions across trials. The order of toy used and trial type was counter-balanced.

5.3.2. Results

Since there were three choices for the subject on each trial, chance performance was .33. The older group of subjects performed well above chance in all conditions, regardless of tense or cue type. The younger subjects were significantly above chance given open class cues in all tenses, while with the closed class cues they performed above chance in the past and present tense but not the future tense. These means are shown in Table 7.

Table 7 Mean Percentage Correct, Tense Experiment

	Open Class Cues			Closed Class Cues		
	Past	Present	Future	Past	Present	Future
Young n = 25 m age = 2.74	.62***	.59***	.63***	.48*	.57**	.43 n.s.
Old n = 21 m age = 3.85	.82***	.95***	.76***	.71***	.88***	.53*

*, $p < .05$ **, $p < .01$ ***, $p < .001$ compared to chance = .33

A mixed design ANOVA was run with age group as a between subjets factor and tense, cue type and telicity type as within subjects factors. A main effect was found for age (older children do better than younger children, $F(1, 44) = 22.13$, $p < .0001$), as well as for cue type (open class cues were better than closed class cues, $F(1, 457) = 11$, $p < .001$) and tense ($F(2, 457) = 5.77$, $p < .01$). Children performed significantly better with the present tense compared to the future tense ($t(44) = 2.0$, $p < .05$) but there was no difference between the present and the past tenses ($t(44) = 1.94$, n.s.) or the past and future tenses ($t(44) = 1.92$, n.s.) The telicity value (telic or atelic) of an event was marginally significant ($F(1, 457) = 3.8$, $p < .053$). No interactions were significant. The lack of interaction effects indicates that the older children, despite the fact that they are well above chance in all conditions, showed improvement with open class cues and with the present tense trials just as the younger children did.

In addition to looking at raw percent correct, it was also of interest to see the pattern of responses that children made: when they didn't get the answer right, what kind of errors did they make? For cases in which the significance value was $p < .001$ or better, which includes all the open class cases and virtually all of the old group's data, the patterns of response were uninformative, primarily because subjects so frequently chose the correct response. However, the response pattern data paints a slightly different picture of the young group's competence with the closed class cues. There are three locations on the road a subject could choose which correspond to the correct answer to the past, present and future tense questions. Table 8 shows the percentage of times that subjects from the young group chose each of these locations given a past tense, present tense and future tense query (closed class cues only). Notice that along the diagonal we see the mean percent correct from Table 7 because these cells correspond to the times when children get the answers right. That is, when given a past tense query the subject chose the past location, given a present tense query the subject chose the present location and given a future tense query the subject chose the future location.

Table 8 Mean Percentage of Times a Location was Chosen by Tense of Query, for Young Group, Closed Class Cues Only

Tense of Query	Location Chosen		
	Past	Present	Future
Past	.48	.38	.14
Present	.35	.57	.08
Future	.10	.47	.43

It appears from Table 8 that different locations may have different base-line rates which should be taken into consideration. This is accomplished statistically by computing a pair of difference scores for each location which compare the percentage of times a location L was chosen given L's appropriate tense to the percentage of times that location L was chosen given the other two tenses. That is, to assess knowledge of the future tense, two difference scores are computed for each subject:

(1) % of Future locations chosen given future tense query — % of Future locations chosen given a past tense query

(2) % of Future locations chosen given future tense query — % of Future locations chosen given a past tense query

The means of these difference scores were calculated and compared to chance, which is zero. A chance score would be generated if subjects chose the future location equally often given each kind of query, thus showing that the tense of the query was not influencing the location chosen. Results showed that the young children did choose the future location given the future tense more often than either the present tense ($t(24) = 5.2$, $p < .0001$) or the past tense ($t(23) = 3.8$, $p < .001$). Thus, although overall the young children are dis-inclined to choose the future location (it has a low base-line rate), and do not objectively choose it very frequently even given a future tense query (recall from Table 7 that their mean correxct with

the future wasn't significantly different from chance), we can still see that they distinguish the future from the past and present.

Equivalent analyses with the past and present locations show that children's knowledge of these tenses is more marginal than might be expected from Table 7. The past location is chosen significantly more often given a past tense query than a future tense query ($t(24) = 4.11$, $p < .001$) but only marginally more often than given a present tense query ($t(23) = 1.84$, $p < .08$). Moreover, the present location was chosen more often given a present tense query than given a past tense query ($t(24) = 2.46$, $p < .02$) but not more often than given a future tense query ($t(24) = 1.64$, n.s.). Thus, this analysis finds children's competence with the past and present tenses to be not as strong as their competence with the future tense, contrary to the straight means presented in Table 7.

An items analysis showed that there was an effect for event type ($F(5, 519) = 2.26$, $p < .04$). This effect, as well as the marginal telicity effect, was driven by the event of FILLING IN A PUZZLE which was more difficult for both groups across all conditions. The overall means for each of the events is shown in Table 9.

Table 9 Mean Percentage Correct by Event, Tense Experiment

	% correct
fill in a puzzle	.46
empty out a cup	.68
draw a face	.64
rest	.66
hop around	.68
play with a friend	.72

In addition, there was an effect for session order: subjects performed significantly better in the first session than in the second session ($t(45) = 2.01$, $p < .05$). This session effect, however, did not appear to interact with any of the variables of interest and so will not be discussed further.

5.3.3. Discussion

These results showed a slight developmental trend in children's comprehension of tense. Children in the older group (equivalent to the middle group in the grammatical aspect experiment) succeeded across the board with all three tenses using either closed or open class cues. Children in the younger group succeeded in all tenses using the open class cues, but given only closed class cues, they demonstrated strong comprehension for the future tense, but only weak competence with the past and present tenses.

How do these results bear on the Aspect First hypothesis? The solid performance by the young group with the open class cues provides strong evidence that the concepts that underlie tense are well understood by the time children are 2.7. Moreover, the fact that telic and atelic events patterned together (both in success and failure) argues against the idea that the young children are using the lexical aspect of the predicate to somehow bootstrap themselves into tense; if such bootstrapping were in fact taking place, we would expect to see an advantage for atelic predicates in the present tense and for telic predicates in the past tense and this does not happen. The young children's weak performance with the closed class cues in the present and the past tense suggests that they may still be in the process of making the adult mappings for these morphemes.

A final, intriguing finding from this experiment was young children's surprising success with the future tense with closed class cues. The future tense does not participate in the Aspect First distributional phenomenon and semantically it is linked to modality as well as tense. It will be discussed further in §5.5.4.

5.4. Comparing Tense and Grammatical Aspect Performance

There were 36 subjects who participated in both the grammatical aspect and tense experiments and therefore permit a reasonable way to compare performance across the two tasks. For this analysis, there are two groups of subjects. The young group consists of 22 subjects with a mean age of 2.7 years (ranging from 1;10 to 3;2) and the old group consists of 14 subjects with a mean age of 3.9 years (ranging from 3;3 to 4;5). The old group is therefore equivalent to the middle group in the grammatical aspect task and the old group in the tense task.

Because there were so many differences between the tasks, the children's performance was compared only on three dimensions: overall performance given open class cues, overall performance given closed class cues, and performance with the past imperfective form. Recall that the past imperfective (*x was V'ing*) was the one sentence type which was used in both experiments, but it applied to different kinds of situations in the two experiments. In the grammatical aspect task, this form was contrasted with a past perfective form (*I V'ed*) and its intended match was the incomplete version of the event (although recall further that in practice, adults applied the past imperfective equally to completive and incomplete event versions). In the tense task, the past imperfective was contrasted with present and future forms (*The kitty is V'ing/is gonna V*) and it was matched to the past action, which was a completed one for telic events and a terminated one for atelic events.

A direct comparison of scores on these dimensions across tasks is not possible because chance performance is different in the two tasks (a score of .55 would be equivalent to chance in the grammatical aspect task but above chance in the tense task). In order to make the relevant comparisons, the scores had to be normalized with respect to chance. This was

done using the following formula: (score – chance) ÷ standard error[51]. Chance was .5 for the grammatical aspect scores and .33 for tense scores; the standard error was calculated from the group means for that score. This normalized score was calculated for each subject for each dimension to be tested and then the mean was taken across subjects' normalized scores. To compare across tasks, a difference measure was taken, consisting of the mean of the normalized scores in the tense task subtracted from the mean of the normalized scores in the grammatical aspect task. Thus, for the comparison of overall performance with open class cues, the following difference score was used:

$$\mu_{\text{normalized}}(\text{open class cues}_{\text{grammatical aspect}}) - \mu_{\text{normalized}}(\text{open class cues}_{\text{tense}})$$

A difference score of zero indicates no difference in performance across the tasks (subjects were equally good/bad with open class cues in the two tasks); a difference score that is significantly positive indicates the performance was better in the grammatical aspect task and a difference score that is significantly negative indicates the performance was better in the tense task. The difference scores are shown in Table 10.

Table 10 Comparisons Across Tasks: Difference Scores

	Open Class Cues	Closed Class Cues	Past Imperfective
young n = 22 m age =2.7	– .21	– .26*	– .123
old n = 14 m age =3.9	– .76***	– .94***	– .94**

* p < .05, ** p < .01, *** p< .001 compared to no difference = 0

All the difference scores are negative, indicating the overall superior performance in the tense task compared to the grammatical aspect task. The old group showed a very significant improvement in the tense task (remember that these children were in the middle

[51] This normalization procedure apparently has some precedent in the priming literature although it is not clear that the current studies meet all the assumptions necessary for such a cross-task comparison even with the socres normalized in this way.

group in the grammatical aspect task) demonstrating better performance across the board. The large difference in the open class cues cell is driven by the weakness of the imperfective aspect open class cues on the one hand and the great strength of the open class cues in the tense task with these children. The young children showed very little difference between the two tasks, showing a significant advantage only for the closed class tense task. However, the fact that there is no difference in the past imperfective cell reinforces the idea that young children's comprehension of past tense was only marginal and thus not significantly better than their chance performance in the grammatical aspect task. The lack of a difference in the open class cues cell for the young children appears to be driven by the strength of their success with the open class perfective condition. These children are clearly succeeding with the open class cues in the tense task, and although they are at chance with the imperfective open class cues in the grammatical aspect task, their high score with the perfective open class cues pulls their overall score for the open class cues in the grammatical aspect task up to something comparable to their performance in the tense task.

5.5. General Discussion

These experiments investigated children's comprehension of tense and grammatical aspect morphology as well their comprehension of tense and grammatical aspect concepts as encoded through open class items. The results showed (1) that open class cues were comprehended at a younger age for both tense and grammatical aspect and they facilitated comprehension even for those subjects who were succeeding with the closed class cues, (2) that the younger children did not demonstrate comprehension of grammatical aspect and demonstrated only marginal comprehension of tense morphology (except for the future tense), and (3) that comprehension of tense morphology appears to precede comprehension of grammatical aspect morphology.

In the following sections, these results will be used to evaluate the Aspect First hypothesis and then will be compared to related work in this area done by Weist and his colleagues. Finally, the implications of these results beyond the Aspect First hypothesis will be addressed.

5.5.1. Evaluating the Aspect First Hypothesis

The Aspect First hypothesis was motivated by the distributional facts found in children's early production (and discussed at length in Chapter 4) and stated that the cause of the distribution was that children were initially using tense and grammatical aspect morphology to mark the lexical aspect property of telicity. Several motivating explanations of this hypothesis were suggested (including two explanations which denied the validity of the hypothesis) which made a variety of predictions about children's competence. What all of these explanations hinged on (with the exception of the semantic affinity account), however, was that children's knowledge of tense and grammatical aspect morphology was, to a greater or lesser extent, non-adult like. In this section, I will consider how the results from the current comprehension experiments bear on these motivating explanations and therefore on the Aspect First hypothesis itself. Note that the crucial data to consider here comes from the youngest groups of subjects, since these children are comparable in age to the children demonstrating the Aspect First distribution.

5.5.1.1. Conceptual Development

The conceptual explanation argued that the Aspect First hypothesis was driven by children's inability to understand the concepts that underlie tense and grammatical aspect. In these experiments, the open class cues provides a way to dissasociate children's comprehension of tense and grammatical aspect concepts from their comprehension of the

relevant morphology. The results showed clearly that the young group of children had a solid comprehension of the tense concepts and, although the support was equivocal, at least some comprehension of grammatical aspect concepts. A variation of the conceptual explanation concerned prototype theory and argued that children would use the telic-atelic distinction as a bootstrap from which to learn about tense and grammatical aspect. The finding in the tense experiment that the two kinds of events patterned together in all conditions (that is, there was no advantage for the telic events in the past tense nor for the atelic events in the present tense), however, suggests that telicity is not a factor in early tense usage. Thus, conceptual inadequacy does not appear to be the right explanation of the Aspect First hypothesis or of the distribution of forms.

5.5.1.2. Linguistic Mapping and Syntactic Development

The linguistic mapping and syntactic development explanations both argue that the Aspect First hypothesis reflected a non-adult like state of the child's grammar but not necessarily of their conceptual system. The syntactic development explanation posited a more serious difficulty for the child to overcome than the linguistic mapping explanation (the inability to create sufficiently large syntactic trees vs. a simple mis-mapping of concepts to morphemes), but both were committed at least to non-adult like performance on tense and grammatical aspect morphology while remaining agnostic in principle about the performance with the conceptual controls. These positions are largely supported by the current experiments because the young group of children failed to show adult-like comprehension with grammatical aspect and showed only marginal comprehension with tense (at least with the past and present); moreover, the children's success with the open class cues does not vitiate these explanations. The current results do not bear on the strong claim of the Aspect First hypothesis, namely that the particular form of the mis-mapping involves using the morphology to mark telicity (either as the result of the tree the child creates or as a simple

mapping mistake), because the experiments were not designed to test for alternative possible mappings for the morphology (i.e., they did not test to see if the young children thought the perfective morphology meant telicity, only if they thought it meant perfectivity). Nevertheless, the non-adultness of the mapping is sufficient to make either one of these accounts a distinct possibility.

5.5.1.3. UG Constraint

The UG constraint explanation argued that children restricted perfective marking to telic predicates (and imperfective marking to atelic predicates) not because of any confusion between the two but simply because that is the most constrained hypothesis given that some languages may in fact restrict grammatical aspect marking in just this way. This explanation makes predictions only for the grammatical aspect experiment; in particular, it predicts that the young children should succeed at least with perfective aspect because the perfective + telic predicate combination is a part of the child's grammar and should have the adult meaning. The current results found no such success and therefore cast doubt on this explanation[52]. This explanation has nothing to say about children's early competence with tense morphology but it isn't clear how children's marginal behavior with the past and present tense morphology could support this account.

5.5.1.4. Semantic Affinity

The semantic affinity account essentially constitutes the null hypothesis for the Aspect First distribution. This explanation stated that children have full knowledge of the

[52] As will be discussed in the next section, Weist and his colleagues have found young children succeeding with grammatical aspect, but his results cannot salvage this account because he found the children succeeding with both perfective and imperfective aspect applied to telic predicates. The UG account predicts an asymmetry between performance on a perfective+telic combination (grammatical for the child) and imperfective+telic (ungrammatical for the child) but neither my experiments (which found children

tense and grammatical aspect morphology and that the distribution merely reflected affinities present in the semantic system, affinities which adults often demonstrate as well. The mediocre performance of the young children with the closed class elements suggests that the semantic affinity account is missing an important element to the story. Young children do not appear to fully know the adult-like meanings of the tense and grammatical aspect morphology and they are not using it as adults do. The absence of adult mappings is not predicted by this account but is a necessary condition for the Aspect First hypothesis.

The one domain where the semantic affinity account seems to carry some explanatory weight is in the successful performance of adults and 5 year olds with the closed class grammatical aspect morphology. Recall that the 5 year olds behaved with a pair of sentences as adults did when presented with a single sentence: they reliably matched a perfective sentence to a completed event but matched an imperfective sentence to an incomplete event only half the time. There seems to be a bias to associate a telic predicate with a completed event, even when the grammatical aspect of the sentence does not require it. This suggests that telicity (the ability to be completed) and completion make good bedfellows conceptually and this conceptual link may be what drives us to assert it so often in language, by putting telic predicates in the perfective where they have an entailment of completion.

5.5.1.5. Final Evaluation of the Aspect First Hypothesis

A necessary pre-condition for the Aspect First hypothesis is that children are not using tense and/or grammatical aspect morphology as adults do. The results from the experiments conducted here found that the young children did not show adult-like comprehension with grammatical aspect morphology and only marginally adult-like

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failing both) nor Weist's experiments (which found them succeeding with both) demonstrated this asymmetry.

comprehension with tense morphology, but did show good comprehension of tense and grammatical aspect concepts as represented by the open class cues. The success with the open class cues rules out the conceptual development account since children appear to have the relevant concepts. The gap in children's knowledge demonstrated here seems to satisfy the necessary pre-condition for the Aspect First hypothesis and therefore rules out the UG constraint and the semantic affinity accounts, both of which posit, to varying degrees, an adult-like competence with tense and grammatical aspect morphology. These experiments cannot choose between the linguistic mapping and syntactic development versions of the Aspect First hypothesis, nor do they determine if in fact telicity is the concept being mapped to the tense and grammatical aspect morphology. They do, however, is establish that these are the right questions to be asking.

5.5.2. Comparison with Weist's Work

The experiments reported here are not the first to test children's comprehension of tense and grammatical aspect. Richard Weist, in a series of papers with a series of collaborators (Weist1983, Weist 1991, Weist et al. 1991, Weist et al. 1997) has looked at children's interpretations under various conditions as well as in various languages (English, Polish and Finnish). The tasks he uses to test grammatical aspect and tense are very similar to the tasks used here, but the results are somewhat different. I will therefore undertake in this section a detailed comparison of these experiments to Weist's, with the aim of determining the sources of the differences.

Weist proposes a theory of temporal development (articulated most fully in Weist 1989) based on the Reichenbachian system of three time points, the speech time (ST), event time (ET), and a reference time (RT) (see §2.4 for more discussion of this approach to tense). Weist argues that children acquire the ability to use these points to define time relations in a developmental sequence. By the age of 2, children have command of the ET

and ST points and so have command of the basic tenses. The RT point comes in between the ages of 2 and 3, but initially operates in a restricted manner: it must be situated at the same time as the ET and is used only to support adverbial modification. About 6 months later, the RT point becomes more flexible, can be used to identify an independent time, and is used for perfect constructions and for combining clauses. The implications of the restricted RT system are somewhat unclear. Weist acknowledges that some temporal adverbs (such as *already*) are produced around the age of 2 years but his experiments are aimed at showing that before the age of 3 children do not make fine distinctions among temporal adverbs (e.g., that they do not understand the difference between *in a second* and *in an hour*). Nevertheless, it seems that one of the predictions of this developmental sequence is that open class instantiations of temporal concepts (like adverbs) should come in later than the basic instantiation of tense through the closed class system.

Weist has conducted several experiments aimed at testing his developmental model. His tasks are all essentially like the grammatical aspect task used here except that he uses pictures instead of acting out the events[53]. For example, in his grammatical aspect task, subjects are shown pictures of a telic event in either completed or incomplete form and are asked to match those pictures to sentence descriptions in the imperfective and perfective. In his tense task, subjects are shown pictures of a telic event that has either completed (e.g. a girl with a snowball on her coat) or is anticipated (e.g. a boy swinging his arm back with a snowball) and are asked to match the pictures to sentence descriptions in the past and future. His test of adverbials contrasted immediate and remote versions of an event. For example a picture of a father and son holding a camera would be matched to *Daddy will take a picture in*

[53] Weist et al. 1997 used videos and the preferential looking paradigm in addition to static picture-book style pictures. The results with the video presentation were qualitatively the same as the results with the picture-book pictures.

a second and a picture of the father and son sitting on a chair next to a camera would be matched to *Daddy will take a picture in an hour*[54].

Weist's results show that English speaking children, by about the age of 2.5, can pass these tense and grammatical aspect tests but they cannot pass the adverbial condition until age 4 or older. Polish and Finnish speaking children show the same general pattern, though in some of the papers, they do not pass the basic tense and grammatical aspect tasks until they are about 3.5 years old. Putting aside his cross-linguistic data, we can interpret these results by saying that the English speaking children understand the closed class encoding of tense and grammatical aspect by age 2.5, but have difficulty with the open class specification of time information until as old as 4 years old. These results are quite at odds with the current results, which found that 2.5 year olds did not completely understand the closed class encoding of either tense or grammatical aspect and that all children tested performed better given open class cues.

How can we account for this discrepancy between the current work and Weist's? The differences in the open class results can be easily attributed to the differences in the tasks. Weist was interested in finding differentiation between times that were either both past or both future. Depicting these differences is quite difficult and seems to require some ability to ascribe narrative to a static picture. By contrast, in the current experiments, the open class cues were used to differentiate between conditions (i.e., between perfective and imperfective in the grammatical aspect experiment and between past, present and future in the tense experiment). Thus, the current tasks did not require fine grained differentiations among the open class cues (such as the difference between *soon* and *in an hour*) but only gross differentiation, such as the fact that an adverbial should be associated with the past or with the future. The current experiments did not tap as deeply into the semantics of these open class cues as Weist's studies did, and perhaps we can interpret the differences in the results as

[54] Weist also investigated combinations using multiple clauses, like *the boy put his pants on before/after he put his shoes on*.

indicating the level at which the children understand the semantic force of these adverbials. Moreover, the fact that the grammatical aspect results with the imperfective open class cues here were decremented compared to Wagner (1997) suggests a link to Weist's results: all open class cues are not equal (not surprisingly) and children face a mapping problem in the open class domain as well as the closed class one.

The differences between these results and Weist's in the closed class domain raise a variety of issues. One possible explanation for the overall worse performance by the younger children in these studies may be the nature of the materials used. Weist used static pictures to represent his events while these experiments used actual toys. The advantage of using actual objects was that my tasks required virtually no training for subjects at any age and the subjects all found the tasks highly engaging. Weist, by contrast, reports (Weist 1991) that he had to spend 1.5 to 2 times as long working with his younger group (compared to his older group) to insure they were properly trained and to get them to complete all the trials. However, the benefits of using more engaging tasks may have been offset by increased attention to the toys at the expense of the test sentences and perhaps led to artificially lowered performance. While this explanation may be true, it cannot be the whole story. It cannot, for example, explain why children performed better with tense than with aspect (given that toys were used for both tasks), nor why the young children succeeded strongly with the future tense and only weakly with the past and present tenses, nor why both adults and 5 year olds chose the completed event 50% of the time with imperfective aspect while in Weist's studies, children reliably choose the incomplete event with imperfective aspect. To answer these questions, we must look more closely at the tasks themselves.

The tense task used here differs from Weist's task in several ways, most notably in terms of the number of choices available to the subject (there were 3 choices in this task and 2 choices in Weist) and the number of sentences the child matched on each trial (1 here and 2 in Weist). The most important difference, however, was the range of tenses used. In the

current task, children were tested on their comprehension of past, present and future. In all of Weist's studies, children were tested only on a future/non-future comparison. That is, children were always choosing between two events where one of those events was always a future representation (the remaining choice was sometimes a present and sometimes a past event, depending on the particular experiment). Thus, Weist's claim that the young children understand tense is based on their comprehension of the future/non-future contrast. This contrast, however, is understood by the young children in the current experiment as well. If we are asking whether 2.5 year old children make a future/non-future distinction, then the current tense experiment agrees with Weist's findings that indeed they do. If, however, we are asking whether 2.5 year old children distinguish among the past, present and future tenses, the current experiment finds that they only weakly distinguish past from present and Weist has no data that bears on this point. To the extent that we are interested in evaluating the Aspect First hypothesis, it is the past/present distinction that we are most interested in, as it is these forms (and not the future tense forms) which are involved in that distributional phenomenon. Therefore, the current tense results are the same as Weist's results where the experiments are comparable; to the extent the experiments are not comparable, the current results bear more directly on the Aspect First hypothesis.

Turning to grammatical aspect, the task used here was virtually identical to Weist's so there can be no question that the two tasks were at least attempting to test for the same thing. The biggest difference between the two tasks was in the portrayal of the two event versions. In Weist's experiments, both the completed and the incomplete event representations portrayed the agent of the action (thus allowing for the form of his query: *Show me where the boy was building/built a house*). In the current grammatical aspect experiment, subjects were presented with the results (or partial results) of the event and asked to match those results to the agent of the action (as determined by the agents' descriptions). Subjects therefore had to transfer the partiality or completeness of the result state onto the partiality or completeness of the event which led to it through some inferential process.

Because Weist showed the agent of the event, subjects had an additional clue to the event itself, namely how engaged the subject was in the event (the subject is quite engaged while the event is ongoing and less engaged after it has been completed), and this may have eased the inferential burden of the task. If indeed the grammatical aspect experiment here is a little bit harder than Weist's, then we have an explanation both for the developmental lag found here relative to Weist's studies (the harder the task, the older the subject needed to pass it) as well as for the discrepancy in imperfective choices even among knowledgeable speakers.

Weist's experiments found that even the youngest group was choosing the incomplete event version as the correct match for the imperfective sentence. This result was not replicated here, as even the 5 year old children, who clearly understood the morphology, matched the imperfective sentence to the incomplete event version only about half the time. The explanation offered here for the oldest children's behavior was that they were performing just as adults do when presented with only a single sentence to match. To make this argument go through, however, we need a reason to expect the subjects in the current task to restrict their attention to one sentence at a time while the subjects in Weist's experiment apparently could take both sentences into consideration. If the current task is truly more difficult than Weist's, that may provide precisely the reason needed. Alternatively, it would be interesting to know how adults perform on Weist's task given only one sentence to match -- it may turn out that the presence of the agent in the event depiction is reason enough to match the imperfective sentence with the ongoing event.

If this analysis is correct, then the current study, along with Weist's study, can help us pinpoint what features of the world children link to the semantics of grammatical aspect. The poor performance of the young children in the current experiment suggests that properties of the affected object or path (the measuring out element of the sentence) are not very helpful cues for grammatical aspect while the success of the young children in Weist's experiments suggests that the presence of an agent acting in an event is crucial for the felicitous application of imperfective aspect. At this point, speculations have outstripped

what is reasonably supported by the data, but the comparison of the subtle differences between these designs has led to some new questions, such as how children learn about the relationship between events and the objects in them and whether the acquisition of grammatical aspect takes place in stages, with children initially able to apply it to the action part of the event and only later able to extend it to the objects acted upon.

5.5.3. On Tense and Grammatical Aspect

The "aspect" the Aspect First hypothesis is concerned with is lexical aspect, and the hypothesis is about whether children are making a fundamental category confusion: do the children use verbal morphology which for adults contributes independent information (tense and/or grammatical aspect) to mark a property (telicity) which is already inherently present in the predicate? The fact that children do not from the outset demonstrate wholly adult-like comprehension of both tense and grammatical aspect opens the door for such an analysis. However, aside from this question of what role lexical aspect plays in determining early morphology use, there is the additional question of how children learn to properly encode the two independent elements, tense and grammatical aspect. Given the frequent morphological conflation of tense and grammatical aspect (Comrie 1976, Dahl 1985), the problem is far from trivial; moreover, given the historical fact that tense and grammatical aspect markers often develop into one another (Bybee et al. 1994), the problem is one that may not always be well solved. In addition, recall from Chapter 4 that some of the production data discussed with respect to the Aspect First hypothesis seemed to point to some early difficulties with the independence of tense from grammatical aspect, regardless of the relationship of either to lexical aspect (cf. the late emergence of the past imperfective form in French and the alignment of past-perfective forms and present-imperfective forms in Polish and Greek).

The experimental data collected here can shed some light on children's developing competence with tense and grammatical aspect. In particular, the finding that children passed the closed class tense trials a full year or more before they passed the closed class grammatical aspect trials suggests that there is a developmental sequence within this domain: the correct mapping for tense precedes that for grammatical aspect[55]. This sequence could arise for a number of reasons and I will consider three here: conceptual development, mapping strategy used, and UG parameterization.

One reason for a developmental sequence may be that children understand the concepts of tense before the concepts of grammatical aspect. The performance on the conceptual controls with the open class items, however, suggests that this is not the case. The young children clearly passed the conceptual controls in the tense experiment and although the open class imperfective cues posed some difficulties to the young and middle aged subjects in the grammatical aspect experiment (probably due to a flaw in the experimental design), the across-task comparison showed no significant difference with the open class cues. In short, the concepts are not driving the developmental sequence.

A more promising explanation of the developmental sequence comes from children's learning strategies, such as the one-to-one mapping strategy endorsed by, for example, Slobin (1985). If we assume that children are pre-disposed to map only a single concept onto each identifiable morpheme and that having assigned a morpheme to a concept they will therefore be reluctant to map a second concept to it unless forced to by the evidence, then we predict that there will be a developmental sequence such as the one we see here whenever a language conflates multiple concepts into a single morpheme. English, in common with many languages, shows such a conflation in this domain: the simple past tense marker codes both past tense and perfective aspect. English also shows a secondary partial conflation because

[55] If we consider Weist's grammatical aspect results in place of those here, for the reasons discussed in §5.5.2, the developmental sequence would be different, with grammatical aspect coming in slightly ahead of tense. I'm going to put aside Weist's results for now because of the inherent difficulties of making

most present tense forms are required to be in the imperfective aspect (only states and generic/habitual sentences use simple present tense forms). If children acquiring English first map tense onto the morphemes *-ed* and *-ing*, then we expect them to be reluctant to also map grammatical aspect onto these morphemes as well and predict a period of time in development (according to these experiments, somewhere between age 3 and 5) during which they show adult-like competence with tense but not grammatical aspect. Of course other factors come into play which complicate this story, not least of all that tense concepts are conveyed through multiple morphemes. In particular, the fact that in the tense experiment the tense information is conveyed primarily through the auxiliaries (*is/was/gonna*), which do not interact strongly with the grammatical aspect system, begs the question of how children using a one-to-one mapping strategy could have mapped tense concepts onto both the auxiliaries (needed for their success in the tense experiment) and onto the verbal affixes *-ed* and *-ing* (needed to block success in the grammatical aspect experiment)[56].

A final possibility is that children's mapping is operating at a global level, and the sequence reflects a system-wide (as opposed to a morpheme-by-morpheme) parameterization choice. As noted in Chapter 2, there are languages which mark only tense (e.g., Hebrew) and languages which mark only grammatical aspect (e.g., Mandarin Chinese) in addition to languages which mark both (e.g., Russian, English). We can imagine that there is a UG parameter which defines each of these three kinds of languages. The developmental sequence found here would arise if children begin by thinking they are acquiring a Hebrew-type language, in which all the relevant morphology maps to tense concepts, and move to a mixed language only when driven to by the evidence (for example, by the ability of the imperfective *-ing* to appear with all three tenses: *is/was/is gonna be V'ing*)[57]. Appealing to a

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developmental claims across subject groups and experimental procedures. By focusing on just the results found here, my discussion can rest on the within-subjects comparison made in §5.4.

[56] These problems are not greatly eased if we assume grammatical aspect is assigned before tense (cf. the Weist data noted above). In that case the mystery is why having assigned grammatical aspect concepts to the verbal affixes block the 2.5 year olds from assigning tense concepts to the auxiliaries.

[57] Or, if grammatical aspect is acquired first, the default setting would be for a Mandarin-type language.

UG parameter in this way is nothing more than re-stating the problem, but it suggests another direction in which to look for the solution. Defining a linguistic parameter is a claim about the structure of the grammar itself and the validity of a parameter will depend in large part on the validity of the analysis of those structures. If a wholly tense-based system (or for that matter, a wholly grammatical aspect-based system) is a linguistic default, then this fact makes predictions at cross-linguistic and semantic levels; for example, wholly tense-based systems should be more prevalent in the world's languages and tense relations should play a central role in temporal semantics, perhaps even to the point of being used to derive grammatical aspect information[58]. In other words, the way a grammar is acquired and the structure of that grammar are parts of the same problem and in some cases, the solutions to the acquisition questions will be found in the way the language is structured.

5.5.3.1. ... and Mood

Looking more closely at the tense results, it appears that a further developmental claim can be made here, namely that mood precedes tense. This claim arises from children's early strong success with the future tense. Recall that in the tense experiment, the young group of children could only weakly distinguish between past and present tense using only closed class cues but did succeed with the closed class future tense. I have treated the future as a tense throughout this dissertation, but it has been argued (cf. Binnick 1991, Harner 1982) that the future is actually a mood, on a par with modal forms like *must*, *should*, and *might*. The idea is that the future differs from both the present and the past in that we don't ever know for sure what's going to happen in the future; we can speak with authority about what has happened to us (*I went to the circus*) and about what is happening to us (*I am at the circus*), but when we talk about what will happen to us, we are making a prediction. The

[58] In point of fact, grammatical aspect is more prevalent in the world's languages (Dahl 1985, Comrie 1976), lending one more bit of credence to the idea that Weist's finding that children understand

future auxiliaries (*gonna, will, shall*) make very confident predications about the future (*I will go to the circus*) but they can be placed on a continuum with the modal auxiliaries (*might, should, could*) which make weaker predictions (*I might go to the circus*). Note that while it is true that the future always entails an element of un-surety, it is not the case that all non-future forms entail surety. Languages with rich mood systems (e.g., Turkish, Bulgarian) often make a distinction between past events the speaker is sure of and past events she is less sure of. English marks unsure past events with conditional forms: *She could have gone to the circus, but then again she could have gone to the opera instead.*

In the tense experiment, the youngest children could clearly make a future/non-future distinction (i.e., they succeeded with the future tense, just like the youngest children in Weist's experiments) but were not as good at discriminating between the non-future tenses, past and present. We can recast this distinction in terms of mood and say that these children were able to distinguish between sure knowledge (past and present) and predictive knowledge (future), while being less able to distinguish between types of sure knowledge (between past and present). Given this analysis, the data here argues for a developmental sequence in the correct mapping of verbal morphology in which mood precedes tense which precedes grammatical aspect[59]. Mood has been put aside throughout this dissertation, but it shares many features with tense and grammatical aspect. Most notably, it is frequently coded through verbal affixes, often in morphemes which conflate the tense, grammatical aspect, and mood information. Thus, it makes sense to talk about mood as part of a developmental sequence involving tense and grammatical aspect.

Adding mood information into the mix raises new issues in explaining the developmental sequence. Motivating the sequence through conceptual development appears even more wrong than before. Although the current experiments didn't test for the understanding of mood concepts per se (the open class cues in the tense experiment focused

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grammatical aspect early is correct.

on temporal relations and not on the actuality vs. potentiality of the events), if the analysis of children's future/non-future performance with the closed class cues is correct, then clearly these children do have the relevant mood concepts. However, young children's solid success with the tense open class cues (as well as their lesser successes with the grammatical aspect open class cues) shows that these young children also do have these other concepts, so they are not bound to understand the world solely in terms of the mood distinction[60].

In addition, from a learning strategy standpoint the future has several positive attributes that might make it easy to identify linguistically. The future used in the tense experiment here (and the form most commonly used by young children) is a periphrastic one (*be gonna V*) which may facilitate its phonological identification in comparison to the past and present which are distinguished (at least in this context) only by the form of the auxiliary (*is* vs. *was*). Moreover, the future is not conveyed through a conflated form. *Gonna* (as well as *will* and *shall*) expresses futurity but bears no grammatical aspect (or other tense) information in itself (the imperfective-perfective distinction is of course be made in future sentences -- *I am gonna V/I am gonna be V'ing* -- but notice it is completely disassociated from the future morphology). This lack of conflation permits a one-to-one mapping to operate smoothly since once the concept [+predictive knowledge] is applied to the future morphology, it will not have to be modified or changed. Finally, there is the suggestion from Tomosello and Kruger (1992) that the learning of verbs proceeds more easily when the relevant sentence is uttered temporally before the event in question occurs. If this is a general property of learning event-related language, then the future is in an advantaged position since the use of the future is only felicitous before an event occurs.

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[59] Or, given Weist's results in which 2.5 year olds succeed both with grammatical aspect and with the future/non-future distinction, it may be that mood and grammatical aspect both precede tense.

[60] In Whorf's analysis of Hopi (1956), he argued, based primarily on the prevalence of the mood system of that language, that the Hopi people were constrained to view the world only in terms of mood concepts (and were unable to understand the concepts such as tense).

5.6. Chapter Summary

This chapter reported the results from two comprehension experiments aimed at determining if children understand grammatical aspect and tense morphology as well as the concepts that underlie that morphology. The results showed that children who are approximately the same age as children who show the Aspect First distribution in their production data (about two and a half years old) do not demonstrate adult-like comprehension of grammatical aspect and only weakly do so for tense morphology (except for the future tense). They do, however, understand the concepts of tense and to a lesser extent, grammatical aspect, as instantiated by open class cues. With respect to the Aspect First distribution discussed in the previous chapter, I argued that these results (1) refute the idea that the distribution indicates children's failure to understand the concepts of tense and grammatical aspect (because of the general success with open class items) and (2) support the idea that children of this age have not yet correctly and completely mapped the right concepts onto tense and grammatical aspect morphology and thus verify a necessary pre-condition for the Aspect First hypothesis. Moreover, I argued that the results supported a developmental sequence for the acquisition of tense and grammatical aspect morphology (independent of lexical aspect) in which tense was correctly mapped before grammatical aspect and mood information (as represented by the future) was correctly mapped before both.

Chapter 6. Conclusion

This dissertation examined time in language from two directions. First, it proposed a formal model of temporal semantics which both covers a variety of temporal phenomena and is computationally simple. Second, it presented the results from a pair of experiments on young children's comprehension of tense and grammatical aspect. The results showed that by the age of 2.5 children do not have full understanding of the closed class mappings for either category, although they do appear to understand the concepts which both encode. To conclude this work, I want to tie these two somewhat disparate halves together a bit more closely both in theory and in practice.

6.1. In Theory: Learnability

The unifying theme of this dissertation is learnability theory. Learnability theory is the formal study of how systems learn. A proper learnability study must specify four parameters: the initial state of the system (the child's initial knowledge base), the final state of the system (the adult language to be learned), the input (the body of evidence available to the child), and a set of learning mechanisms. The goal of learnability theory is to show that the learning mechanisms can move the learner from the initial state to the final state by means of the input available. With respect to temporal semantics, the child's initial state is described by the model presented in Chapter 3. The final state consists of the language-particular mappings to the model, which was covered at a descriptive level in Chapter 2. The input to the child consists of the language she hears (primarily from her parents) and the properties of this input were discussed briefly in Chapter 4. The bulk of Chapter 4 and all of Chapter 5 investigated the time-course of the mapping process, which is a necessary part of understanding what kinds of learning mechanisms the child might be using.

The one piece of learnability theory that has not yet been addressed is the set of learning mechanisms, or, how in fact the child goes from simply having abstract semantic representations to having temporal language. Since the child has no direct access to the semantic structures that correspond to the sentences she hears, she must deduce these from either the evidence in the world around her, or from what linguistic elements in the sentence she does understand (cf. the bootstrapping debates, Pinker 1984, 1994, Gleitman 1990, Fisher et al. 1994 among others). In the following sections, I want to touch briefly on how the child might move from A to B by identifying the situations (both in the world and in the language) from which the child could learn the right mappings.

6.1.1. Lexical Aspect

The key element to be learned in the lexical aspect domain is how the target language marks the presence (or absence) of a coda in the lexical aspect machine. This poses a bit of a dilemma because languages don't mark lexical aspect in a clear-cut fashion: as noted by van Hout (1998), telicity tends to correlate highly with a variety of linguistic markers (such as transitivity and definiteness) without being reducible to them. Only occasionally is telicity marked directly with particles or case marking. The lexical aspect learning problem can be seen largely as part of the general problem of learning the meanings of verbs and nouns; knowing the meaning of a predicate means knowing whether it describes an event which has a natural end-point. Therefore, the learning mechanisms appropriate to word (and especially verb) learning are similarly appropriate here.

6.1.2. Grammatical Aspect

Grammatical aspect poses a learning problem on two fronts. Differences in perspective often don't correspond to any difference in the world, since the perspective

information encodes the way the speaker is thinking about the event, and not properties of the event itself. This problem is compounded on the other side by the fact that differences in grammatical aspect don't always correspond to structural differences in the semantic analysis: for atelic lexical aspect machines, a machine could stop in the same state for both imperfective and perfective grammatical aspect (though of course, for different reasons). Moreover, since perfective grammatical aspect allows the lexical machines to run their natural course, the model doesn't distinguish strongly between the lexical aspect machines themselves and those machines subordinated to perfective aspect (which may provide a partial explanation of the Aspect First data presented in Chapter 4).

The most informative structure in the model is a telic predicate in the imperfective aspect since it is in this case that the grammatical aspect machines have the most pronounced structural consequences -- they actually alter the truth conditions of the basic lexical aspect machine. Fortunately, an ongoing telic event (i.e., in the present imperfective) is the most informative situation from the world for identifying the semantics of grammatical aspect. Suppose a parent says to a child *I'm making you a sandwich.* Once the child knows what the predicate means (which requires some learning in itself), she knows that the event has a natural end-point that corresponds to a sandwich. Yet the situation at hand presents no sandwich but only sandwich parts (bread, peanut butter, etc.) and this creates something of a paradox for the child -- the word *sandwich* is being applied to something which isn't really a sandwich. To resolve the paradox, the child must learn when *make a sandwich* can be used to refer to the preparation of a sandwich and not its completion. That is, these situations should force the child to look for a marker of imperfectivity and from that point the child is in a position to learn the general mappings for grammatical aspect.

6.1.3. Tense

One of the child's important sources of evidence for determining the meaning of a sentence (and hence its semantic structures) is what's going on in the world at the time the sentence is uttered. The time-lock between the events in the world and the time they are talked about, however, is not very good (Gleitman 1990). That is, we very often talk about events when they are not occurring (e.g., we tell the child to eat her peas precisely when she is not eating them) and we also fail to talk about events as they do occur (e.g., we fail to announce every time we stand up or walk around), much to the chagrin of the easy world-to-word pairing story. Tense, however, is one instance where both a successful time-lock and an unsuccessful time-lock can be informative. The present tense is used primarily for those cases where the time-lock is good: the sentence *I am walking* would be true only if uttered at the same time that the walking occurred. The past and future tenses, on the other hand, are used for those cases where the time-lock is bad: *I walked* and *I will walk* refer to events that do not take place at the time of utterance. The time-lock information can only be exploited, however, by a child who already knows the meanings of the content words in the sentence. In the examples above, the child must know what *walking* means in order to know if there was a walking event time-locked or not to the utterance.

Perhaps somewhat easier cues for the child to use consist of specific linguistic indications of the timing of the event, such as temporal adverbials (e.g. *yesterday, later*), or, even more helpfully, phrases which provide a temporal frame, such as *when we were at the circus*. If we assume that the child knows words like *circus* and can remember when she was there -- and there's good evidence that children aged 2 years old and younger can remember what they did in the past (cf. Nelson 1986, Bauer and Mandler 1989) -- then the child can use her memory to identify the sentences as referring to the past, which can in turn lead her to find the past tense morphology. Frames for the future tense would work in a similar manner but would depend on children's ability to plan and have expectations. This approach of using

open class cues to learn tense is bolstered by the experimental evidence presented in Chapter 5. In both the experiments, but particularly in the tense experiment, children demonstrated good understanding of the open class cues before they understood the closed class morphology. The reasons that made open class cues an experimental convenience for tapping conceptual competence (such as the fact they are typically learned first) makes them an equally valuable resource for the child acquiring closed class temporal language.

6.2. In Practice: Making the Temporal Connection

Periodically throughout this dissertation it has been noted that there is a semantic affinity among telicity, perfectivity and pastness on the one hand and among atelicity, imperfectivity and presentness on the other. In Chapter 2 (§2.3) we saw the affinities at work at the grammatical level, first in the bleeding-down relationship in which perfective markers effectively marked telicity, and again in the implicature from pastness to perfectivity (and vice-versa) and from presentness to imperfectivity (and again vice-versa) in languages which grammatically marked only one of tense and grammatical aspect. The affinities were raised again in Chapter 4 as a possible explanation of the Aspect First distributional hypothesis as well as of the fact that adults may be showing the same kind of distribution of forms that the children do.

Despite the potential explanatory value of understanding this semantic affinity for the problems discussed here, this dissertation has offered no account of it. In this I follow the general literature on this topic: no one has ever offered a satisfactory account of this semantic connection. The experimental data here with the open class items confirms that the connection does not reduce to conceptual confusion among the categories, but the fact that the semantic affinity extends into the grammars of languages, as well as the fact that adults may demonstrate the same sort of production biases, should already have been enough to convince us that the semantic affinity is more than just an error pattern.

The semantic affinity seems to revolve around grammatical aspect, which is semantically connected to both tense and lexical aspect, but in different ways. The relationship between tense and grammatical aspect is one of partial redundancy. It can be illustrated by a set of one way probabilistic implications. Putting aside the future tense (which does not seem to be a part of these connections), the following implications are usually true:

(140) If a predicate is in the perfective aspect, it has past meaning
(141) If a predicate is in the present tense, it has imperfective meaning

The implication in (140) is usually true because the perfective aspect requires evidence of completion or termination of the event and such evidence is best collected off of whole time intervals; the only time intervals for which we know what happens in their entirety are those in the past. The reverse holds for the implication in (141). The present tense necessarily picks out a time interval that is ongoing which makes it very difficult to successfully find a perfective meaning but which is perfectly compatible with imperfective meaning. A clear exception to these implications is the English present perfect construction (*Otto has visited Baraboo*) which combines the present tense with perfective meaning. However, there is a large literature trying to pin down the meaning of the present perfect construction (e.g. Comrie 1976, McCoard 1978, Spejewski 1997), much of it devoted to the question of how (and to what extent) the present perfect actually combines past and present meaning (perhaps arising from the attempt to satisfy both implications). That is, the infrequent cases in which these implications are not true stand out sharply as unusual semantic constructions.

Grammatical aspect is also semantically connected to lexical aspect. There is a formal connection between atelicity and imperfectivity in that imperfectivity forces the halt state of all lexical aspect machines to be in what is the natural (and inevitable) halting state for an atelic machine. However, neither formally nor intuitively is an imperfective telic predicate the same as an atelic predicate. Whether it is reached or not, the end-point of a telic predicate serves to define the shape of the event as a whole, and, while adding the

imperfective meaning may remove the entailment of completion, it does not alter the essential structure of the event.

The connection between perfectivity and telicity may be derivable in part from pragmatic considerations. A telic predicate in the perfective aspect makes a positive assertion, namely that the end-point has been reached while a telic predicate in the imperfective is open as to whether the end-point is ever reached. If a speaker is following the Gricean maxims (Grice 1968) and attempting to be as informative as possible, she will be pushed to put telic predicates into the perfective aspect because that is the most informative form for them. If the speaker knows that a house was built, then she should say so by putting the predicate in the perfective aspect (*Otto built a house*); it would be misleading for her to say *Otto was building a house* leaving open the possibility that it wasn't finished. Atelic predicates are not subject to the same pragmatic considerations, since grammatical aspect does not influence the number of entailments that can be drawn from them.

I do not offer these speculations as an actual explanation of the semantic affinity between grammatical aspect and tense or between grammatical aspect and lexical aspect (let alone between lexical aspect and tense) but simply as a way of demonstrating how much of an explanation is needed. These semantic relationships influence the way our grammars are structured and the patterns that we find in children's early speech; an explanation of them could therefore shed light both on the way that temporal semantics is organized as well as on the learning mechanisms the child uses to map temporal semantics to her language. In practice, then, we have a conceptual gap that needs to be filled if we are to understand how temporal semantics is organized and how temporal language is learned.

6.3. Conclusion

I have concluded thus far by raising two problems. The major theoretical problem to be solved is How does a child learn to map her language onto her semantic structures? and the

major practical problem to be solved is What is the real connection among the temporal levels? The work presented in this dissertation has addressed these two problems at two levels. First, it has provided an explicit semantic analysis which, in addition to simply accounting for a wide range of temporal phenomena, can be used to make predictions about how children might learn temporal language, and may also help us formalize the semantic connection among tense, grammatical aspect, and lexical aspect. Second, it has expanded our knowledge about the time-course of children's acquisition of temporal language, allowing us to see what it is that children in fact need to learn (the mappings, not the concepts), and helping us to see what kinds of information a child might use in learning temporal language (such as open class cues, or, as discussed in §5.5.2, perhaps information about agentive participation). The over-arching problems, of course, remain unsolved, but this work has moved us, ever so slightly, towards their answers.

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