Aspectual Shift as Supervaluation

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Abstract: The phenomenon of aspectual shifting in connection with temporal adverbial modification is normally theoretically handled on the analogy with type-coercion in programming languages. It will be argued here that this analogy is not as close as generally assumed and following it too strictly has prevented linguistic research from uncovering the source of the adaptive power of natural language. The paper develops a new type of approach within the framework of finite-state temporal semantics. The heart of the proposal is a supervaluational concept of underspecification, and the idea of treating the meanings of temporal prepositions as dynamic presuppositions. The simple shifting algorithm used derives the correct set of possible readings on the basis of lexical semantic input only, and, furthermore, may claim cognitive plausibility.

1 Introduction: Aspectual Shift

A common motivation for any linguistic investigation into the field of temporal semantics is the question of how natural language is used to encode the temporal structure of the world. Depending on how this question is answered, one may wish to learn about natural language itself, try to draw conclusions concerning basic principles of human cognition, or one may aim at using theoretical linguistic insights for practical applications (such as temporal information extraction or temporal databases).

The referents of temporally determined sentences are usually talked of as *situations*. The traditional ontological classification schema (e. g., Kenny [17], Vendler [33]) divides the respective situational types into at least four abstract subclasses: *states, activities, accomplishments* and *achievements*. This aspectual taxonomy takes into account the internal temporal structure of the situations, and is based

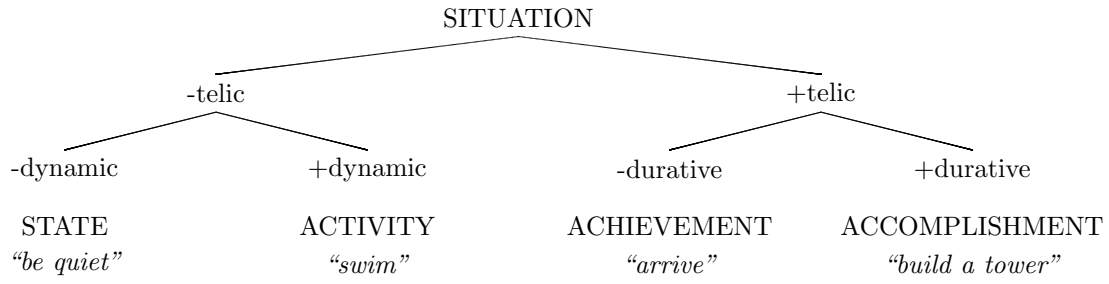

Figure 1: Aspectual classes.

on a small number of features, such as: *telic, dynamic, durative*. Intuitively, dynamic and telic situations involve change with respect to a certain property or relation. Thus they can only be verified with respect to temporally extended intervals rather than moments. Those changes can be directed towards a goal, as in the telic case, or proceed without an inherent halting point, as in the atelic case. Since telic situations are inherently bounded, none of their proper temporal parts can be an instantiation of the very same situational type as the original situation. For the same reason, it is possible for a telic situation to be interrupted before being fulfilled. Finally, the transition towards the result states can take place gradually or momentary (relative to a contextually supplied standard). The durativity feature is used to mark this difference within the class of telic situations. Figure **??** displays the resulting classification schema.

Situations are referred to by verbal phrases. Differences in truth conditions, presuppositions and entailments of the respective sentences, as well as effects on temporal sequencing in discourse are plausibly built on the aforementioned structural differences. That the assumed ontological aspectual classification is reflected on linguistic level is (at least partly) borne out by a number of language internal testing procedures, such as grammaticality effects in connection with imperative, progressive, pseudo cleft and adverbial constructions.

While aspectual classes are sometimes thought to be a means to classify verbal lexical entries, closer investigation reveals that the aspectual character of a verbal phrase can change during the process of semantic composition under the influence of, for instance, nominal arguments and prepositional phrases, tense and aspectual markers, aspectual auxiliaries, or temporal adverbials. Accordingly, the aim of a theory of aspect is to "*determine how the aspectual characteristics of complex phrases are determined by those of their parts*" (Kamp and Reyle [16]:570).

In the last thirty years, considerable progress has been made in formally describing the aspectual contribution of nominal and prepositional arguments (e. g., Verkyl [34], Krifka [19]). However as far as the aspectual behavior of temporal adverbials is concerned, some puzzling sets of data still await proper explanation and an appropriate formalization. The observation that problems arise at this point is

particularly worrying given that the very same types of examples are standardly used as linguistic test cases to differentiate telic from atelic verbal phrases. Therefore, if we could find significant problems with the theory just here, the whole idea of a language internal criterion for the division of verbal expressions according to the aspectual situational schema would suddenly become vague and ungrounded. However, postponing all aspectual determination to a language external level, and using widespread contextual and background information (compare with the idea of a two-level semantics by Bierwisch [2]) would take it out of the reach of any effective formal treatment, as far as theoretical matters currently stand.

The troublesome examples under discussion test for compatibility of a verbal phrase with "for" and "in"-adverbials. According to observational facts - so the traditional story goes - atelic states and activities admit modification by a "for"-adverbial, but give rise to ungrammaticality when combined with an "in"-adverbial. For telic achievements and accomplishments things are precisely the other way around. The examples in (**??**) and (**??**) briefly repeat this well-known pattern.

(1) *be quiet for an hour / *in an hour*
*swim for an hour / *in an hour*

(2) *arrive *for an hour / in an hour*
*build a tower *for an hour / in an hour*

However, after closer inspection, these canonical test cases do not seem to be as simple and clear cut as one would like, given their fundamental theoretical status. The marked phrases, far from being ungrammatical, quite naturally display several kinds of meanings. The focus of the "in"-temporal adverbial in (**??**) can be read as being shifted from the situation itself towards its *pre-phase*, which is the lead up to the swimming process or to the state of being quiet an hour later than the present. In cases where an *implicit boundary* for the activity is given by context (e. g., a triathlon competition) the process itself can be also modified by the adverbial. For the telic examples in (**??**), an *iterative* interpretation appears to be available, with the "for"-adverbial giving the duration of the whole complex situation rather than just one of the included basic events. Another interpretational possibility here is to let the adverbial fix the duration of the *preparatory phase*, i. e., when the change is under development, which precedes the culmination of the situation. Finally, the "for"-adverbial is also able to modify the *result state* following the culmination of the event.

In essence, the statement of ungrammaticality with respect to the marked cases, as put by traditional theories of aspect, clearly turns out to be untenable in face of the real semantic facts. Figure **??** summarizes the data concerning the existence of shifted adverbial interpretations. Notably, following the steps of the

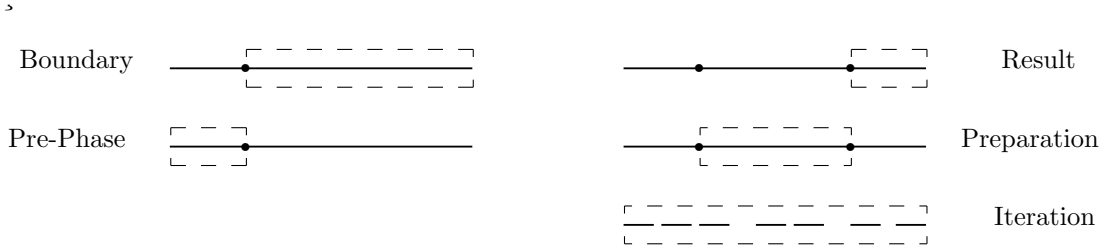

Figure 2: Aspectual shifts for atelic (left) and telic (right) situations.

various shifting operations leads us to a representation of a situation as a complex unit that comprises different phases and is defined with respect to a certain pattern of change. The drawn lines in the figure illustrate the course of an event, as it is unfolding in time from left to right. In the case of atelic situations, the shifting effects mark a twofold partition into *pre-phase* and *application phase*. For the telic case, the schema additionally needs to differentiate a *result state*. Aspectual adverbial shifts then appear to proceed via focusing different segments of that line, as indicated by the dashed boxes. At first sight however, the iteration example appears to not fit this general schema. Here, every line segment refers to a complete event, and the shifting focus of the adverbial seems to trigger a multiplication of the entire original structure. Nevertheless it will be a challenge for any attempt at semantic formalization to try and derive all the cases with the help of just one general principle.

To better fix the path of the prospective theoretical investigation, an initial qualifying remark is required. For the above shifting schema to have any chance of gaining ground as a basis for proper systematization, it is necessary to delimit those cases of aspectually triggered meaning shifts which are considered here from a number of related but different semantic phenomena. For instance, there are cases (e. g.,"hiccup all day") where aspectual shifts appear to follow solely from conceptual background knowledge concerning default durations of certain sorts of events, rather than being caused by any conflict in aspectual type requirements. I take this sort of phenomena as lying outside the scope of any formal semantic treatment and will not deal any further with them here. Similarly, the following discussion will disregard the possibility of generic interpretations, as these seem to obey contextual semantic principles different from those used to handle the aspectually motivated semantic adaptions described above. This can be seen, for instance, by considering the possibility of generic interpretation of the same verbal phrase in connection with both, "for" as well as "in"-adverbials (e. g., "usually play the sonata for an hour / in an hour").

A second remark is necessary with respect to the examples given above. While the presence of an aspectual clash is not a necessary condition for some kind of

meaning shift to appear, as discussed in the previous paragraph, it is not a sufficient one either. For instance, for the result state reading of a modifier to be available, the result state of the modified telic situation has to be a temporary one (e. g., "walk a mile *for an hour" vs. "open the window for an hour"). Accordingly, the mechanism of aspectual shifting appears to be sensitive to additional, more specific lexical semantic conditions. An approach exclusively based on the assumed opposition of telic versus atelic verbal phrases can therefore never be more than just the first and most general step in the direction of a more comprehensive theory.

Even with these qualifications, the remaining group of aspectual semantic phenomena has proven to be notoriously difficult to systemize and formally treat in any kind of available framework. At the same time, the observed cases do not have the status of real exceptions, but appear cross-linguistical and spread over the whole verbal lexicon. Semantic flexibility of the kind temporal adverbials display seems therefore to challenge linguistic research towards rethinking the theoretical concepts which have been underlying the semantic analysis of situational aspect. If one wants to keep the fundamental theoretical idea of the language internal reality of the opposition between telic and atelic verbal aspectual classes, and, furthermore, continue to use compatibility with "for" and "in"-adverbials as the standard means of classification, one obviously urgently requires an explanation of how the above interpretations can arise. A reasonable way out of the dilemma would be to assign them the formal status of being derived or *secondary readings*, which linguistic theory allows and predicts to occur in result of the application of some kind of repairing mechanism, while at the same time keeping the basic aspectual interpretational schema in (**??**) and (**??**) principally intact.

The aim of this paper is to work out such a semantic analysis of the cases in question which allows the derivation of the correct set of possible interpretations in a simple and fully compositional manner.

2 The State of the Art: Type-Coercion

Before turning to my own proposal for an analysis of aspectual meaning shifts in connection with the interpretation of temporal adverbial modifiers, let me briefly discuss the idea that figures prominently in virtually all recent approaches (e. g., Pulman [26], de Swart [29], Pustejovsky [27], Parsons [25], Egg [8], Dölling [6]). I am going to argue that by following this general line of thought too strictly, linguistic research has so far failed to answer the question about the source of the semantic flexibility of temporal adverbials. The claim to be made in this section is that the problems one can point out come about inevitably and for principle reasons. And that they should be seen as the result of an attempt to take a good metaphor too literally.

Moens and Steedman [20] conceived temporal adverbials as "*functions which 'coerce' their inputs to the appropriate type, by a loose* [sic!] *analogy with type-coercion in programming languages*". Under the perspective implicit in the quotation, aspectual shift is triggered in the cases under consideration by a conflict between the aspectual type of the situational concept to be modified and the aspectual constraint set by the temporal preposition heading the modifier. Coercion operators, then, are thought to adapt the verbal input on the level of the model-theoretical interpretation of the expressions by mapping one sort of situation onto another. The underlying model is commonly supposed to include situations as first-order objects of the four basic types previously mentioned, i. e., *states, activities, accomplishments* and *achievements*.

A first problem is immediately evident with this approach. Since the temporal prepositions constrain the aspectual type of the situation only as far as telicity is concerned, the relation established between the objects in the model by coercion cannot be *functional*. As there are no types *telic* and *atelic* but just two more specified primitive types for each case, which fulfill the respective aspectual requirement equally well, application of coercion inevitably leaves one with several possible outputs. Since, on the other hand, in examples of real type-coercion as applied in programming languages, the introduced relation is always functional, a first clear, formal difference between the shifting operations in the two domains has to be noted. A simple mapping between two primitive situational types cannot formally describe the situation in cases of meaning shifts triggered by temporal adverbials, because the relevant formal criterion is too general to effectively constrain the output type.

This problem becomes even more serious when we take into account the variety of aspectual shifts that actually occur according to the previously given examples. There it becomes clear that even if confined to one of the assumed primitive ontological sorts, the output value of the operation would still remain underspecified. So, for instance, after applying a "for"-adverbial to an accomplishment, the iterative and the result state interpretations count equally as stative. According to the type-coercion paradigm, however, in order to remedy ungrammaticality just one such type-adapted output value would have been sufficient. The fact that there is this exact number of readings therefore becomes a miracle, which the theory is unable to explain and formally account for.

On the one hand, when the telicity/atelicity constraint is associated with the temporal adverbial in the known way, it generally seems to be too loose with respect to the observed transitions, at the same time it appears to be too restrictive. In the boundary reading listed in Figure **??**, the adverbial is successfully applied to a situational concept carrying the wrong telicity feature without any visible aspectual shifts occuring. The common way to prevent the type-coercion paradigm

from being led into contradiction at this point is to assume the situational input as already being implicitly telic due to contextual background information (e. g., Steedman [30]). However, this results in a significant deviation from lingusitic surface appearance, which reduces the theoretical attractiveness of this proposal.

How do these very general problems present themselves within the known theoretical approaches? When analyzing the overall structure of those systems, one finds that in the course of semantic composition, coercion operations get introduced as metavariables. These variables are instantiated by a variety of concrete operations which relate the input situation to an output situation in all the possible ways. The answer to the decisive question of which functions are actually the possible ones here, however, is just read off the data. From theory alone nothing beyond the telicity/atelicity requirement for the output value would follow, and even this prediction is not strictly borne out, as was argued in the previous paragraph. Therefore, the solution has just been given by empirical observation rather than derived through any theoretical systematization. At this point semantic formalization obviously has become a mere record of the data without further explanatory power.

The real task of a future linguistic theory of aspectual shift would be to uncover the general principle or rule that governs the transitions on their several paths, and formally implement it in a way such that all possible readings become strictly derivable within the theoretical framework itself by using lexical semantic information and general rules for combining them only. Furthermore, if linguistic theory wants to be a model of the rational processes that may really underly the faculty of language, this principle should serve to explain the strategy behind this process in a plausible manner.

In order to get a first idea of the nature of the possible principle or rule we are in search for, it is useful to go back to the approaches under critique one more time. When taking a closer look at the set of functions that are wrapped inside the so-called type-coercion operation there, it becomes clear that those do the actual adaptive work by fulfilling transitions within some kind of complex ontological network (compare e. g., Moens and Steedman [20]). The ontological relations between the elements in the model established by these functions are much more fine-grained than what a simple mapping between two abstract, primitive types could have induced, and, intuitively, appear to be of mainly two kinds. Firstly, a situation gets linked via operations like *Result* or *Preparatory Phase* to other situations that are temporally included in or adjacent to it. Secondly, there happen to be functions like *Bundle* or *Add-Culmination* whose input and output situations are commonly described as being different ways of viewing an episode, for instance by taking into account or abstracting away from its internal structure or culmination point.

With respect to this second type of theoretical construct a clear, critical question seems to inevitably arise. Where and of which kind is this third situation that these two situations in the model are different characterizations of? In order to make sense of an idea such as the one of different levels of granularity, the elements that get related to each other during the process of aspectual shifting have to be understood not as different ontological entities but just as different *representations* of one and the same entity. Consequently, a formal semantics of aspect is describing descriptions of structures, rather than structures themselves (compare e. g., Steedman [30], Klein [18], Bach [3], Fernando [11]). In other words, if in one and the same observational situation we are principally free to chose between aspectually different linguistic descriptions, aspectual classes should be understood as "(...) *ways of viewing a happening, rather than intrinsic properties* (...) *of reality and the external world*" (Steedman [30]). Therefore, the relevant differentiations are to be instantiated on a conceptual rather than on an ontological level.

Additional evidence is lent to that view by the observation that a more thorough investigation of the first kind of shifting relation mentioned above is pointing in the same general direction. A proper definition of the functions in question (e. g., *Result* or *Preparatory Phase*) would have to rely on the notions of causality and planning. However, as extensively discussed in the traditional philosophical literature as well as in a lot of current work in the field of artificial intelligence, those go beyond anything that could be formulated in pure temporal or observational terms, and essentially rely on the cognitive make-up of rational, goal directed agents.

Furthermore, by having set theoretical focus on the ontological level when implementing aspectual shifts, linguistic research has taken up a perspective entirely extrinsic to language and the adaptive powers of meanings themselves. As a result of following the type-coercion metaphor, language comprehension here is seen as proceeding via an implicit series of program clashes, only to be repaired by simply no longer obeying the compositional rules for combining lexical semantic information. However, according to the representational view taken up in the one before paragraph, the manipulations at work in cases of aspectual shifting take place within the realm of *Fregean sense*, rather than that of *reference*. The denotation of a situational expression gets constantly re-computed, as semantic composition proceeds, via the systematic modification of its meaning.

The problem of formally defining and deriving the possible shifting operations, which we found inevitably arising inside the type-coercion paradigm, should be expected to have been solved at the same time. By not only involving information concerning ontological type but also semantic information proper, the process of aspectual transition should effectively determine the denotation of the respective output situational concept. At this point then, the phenomenon of aspectual shift

could be said to really have undergone systematic theoretical explanation within a genuinely linguistically inspired and defined framework.

Summarizing the results of the critical discussion of the type-coercion paradigm, I claim that the analogy between aspectual shift as triggered by temporal adverbials and type-coercion as known in the programming language domain is not as close as generally assumed, and surely does not recommend itself for direct implementation. Applying the formal mechanism used in the latter case too strictly and blindly to the former inevitably leads to the interrelated problems mentioned above, and seems by now to obstruct a deeper understanding of what is actually going on when senses change and adapt of their own accord.

3 The Framework: Situations as Strings

In this section, I will shortly introduce a decompositional approach to event semantics within the framework of *Dynamic Logic* that has been proposed by Naumann, together with a finite-state version of it developed by Fernando. The latter theory will give the formal basis for the proposal to be presented.

The decision to apply this kind of formalism in the present context was motivated by the intuition that what was needed to appropriately handle aspectual semantic phenomena was the concept of a situation as a complex but logically coherent, dynamic unit. That means, if aspectual features are defined with respect to some internal, temporal structure of a situation, and if aspectual transitions proceed via shifting focus of an adverbial along the time line from one part of that structure to another (compare Figure **??**), this structure must be represented by the formalism expressing the related situational concepts and, furthermore, has to be made easily accessible by the formal operations that manipulate it. Obviously, the traditional semantic approach in the spirit of Davidson [5], where events are seen as indivisible *atoms*, and modifiers as just indifferently predicating over such atoms, is not a convenient formal tool in this respect. Similarly, if this aspectually relevant, internal structure is defined as encoding different abstract courses of change, evaluation of a situational expression must not take place *statically*, with respect to a single, fixed time index, but needs to take into account the change of truth-value of a certain proposition over several such indices. What seems to be required, accordingly, is a *subatomar* and *dynamic* approach to event semantics.

Quantificational Dynamic Logic (QDL) is usually applied in the context of program specification and verification, but has also turned out to be a convenient formal means for decomposing and making dynamic situational concepts. It differs from classical, static approaches in that the valuation of a formula is mutable, and that the possibility exists, within the framework itself, to put it in relation to other valuations. The syntactic constructs that add these dynamics to the common

system of first-order logic are called *programs*, which, intuitively, can be understood as some kind of *state transformers*. The underlying model defines a set of *states* by valuations of a set of variables over a first-order carrier. An atomic program, then, changes one state into another by assignment of a value to a variable. More complex, *regular* programs can be built with the help of the operators *composition* ;, *choice* $\cup$, and *iteration* *. The fundamental syntactic units of QDL, programs and first-order formulas, interact my means of the *modal* logic construct [ ] and the *test* operator **?**. Intuitively, the resulting constructions are meant to have the following meanings (with Φ being a program, ϕ a (first-oder) formula, x a variable, and t a term):[1]

$[\Phi]\phi$	"after every terminating execution of Φ, ϕ is true"
$x := t$	"assign the current value of t to x"
$\phi?$	"test ϕ: continue if ϕ is true, otherwise fail"
$\Phi; \Psi$	"execute Φ and then Ψ"
$\Phi*$	"execute a nondeterministically chosen, finite number of times"
$\Phi \cup \Psi$	"choose either Φ or Ψ nondeterministically and execute it"

As can be seen from this, QDL is built by merging three complementary classical systems: first-order predicate logic, modal logic, and the algebra of regular events. The resulting system has proven to be "*theoretically rich as well as practical*" (Harel, Kozen and Tiuryn [14]:1). But while for the propositional version of Dynamic Logic there is a sound and complete Hilbert-style deductive system, for the first-order version there is not. That means, one has to carefully distinguish the matter of constructing logical forms from that of drawing inferences on them. Another theoretical result particularly relevant in the context of linguistic investigation concerns the expressive power of QDL. As shown by Muskens [21], QDL subsumes DRT and is subsumed by a dynamic version of Montague Semantics based on classical type logic. The latter fact opens up the possibility of building up dynamic representations in a compositional manner, down to the level of single words or morphemes.

Taking up the dynamical point of view, Naumann [23], [24] incorporated the moment of change into the semantics of verbs by looking at them as a certain kind of complex programs. The value of the variable that gets changed during execution is thought to have been contributed by verbal meaning or co-occurring prepositional phrases, or to correspond to a particular property of the verb's object (*incremental theme*). For this idea to work, the underlying domain is structured as a complete partial order, with an operator $\oplus$ on chains in that order such that x$\oplus$1

[1] A precise definition of the syntax and semantics of QDL, as well as a thorough introduction into Dynamic Logic is to be found, for instance, in Harel, Kozen and Tiuryn [14].

gives the least of all an elements in the chain which are above the current value of x (as long as there is such element). Quantificational information, coming from the determiner or preposition, controls the execution of the program via a test. If the quantificational information is *definite*, the corresponding testing condition will make the program terminate after a definite number of steps. If it is *indefinite* or empty, however, the resulting condition is an invariant of the program, which lets it going on indefinitely. The examples below give the representations of the aspectual logical form of a telic concept (let us say "eat three apples") in (**??**), and of an atelic one (such as "eat apples" or "eat") in (**??**), in the language of QDL.

(3) a. $((x \neq 3)? \ ; x := x \oplus 1)^* \ ; (x=3)?$

b. $((\exists n.\ x=n)? \ ; x := x \oplus 1)^*$

Within this formal setting, the telic/atelic distinction corresponds to the terminating/non-terminating property of a program. Once again, the relevant condition is fixed on the conceptual, not on the ontological level, as the actual length of computation sequence may well be identical for both cases (namely, if the non-terminating program gets stopped from outside, where the terminating one finishes by itself).

The implementation as developed so far accounts well for the dynamics of situational concepts and the different ways these dynamics get controlled by added semantic information. With respect to the phenomenon of aspectual shift, however, this solution should still turn out to be insufficient. Since a program is interpreted as a relation between input and output states, the formalism does not give access to any *intermediate states* encountered during the course of the program. Therefore, there is still no room for anything like the shifting of adverbial focus from one part of that internal structure to another. It seems that in order to give a rich enough formal representation of a situational concept so as to allow this kind of aspectual effects to be taken into account, a program would actually be needed to be interpreted not as a set of pairs of states but as a set of entire finite computation sequences or *traces*.

The theoretical insights that can be understood as connecting Naumann's with Fernando's version of a dynamic situation semantics are the following. If one takes the traces of a regular program, one gets a *regular set of strings*. This set of strings can be represented by regular expressions, accepted by finite-state automata, that, again, may amount to finite Kripke models with partial valuations. In the finite-state approach developed by Fernando [9], [10], [11], [12], a situational concept is accordingly characterized as a *regular language*, each string of which is viewed as a temporal sequence of observations or a *comic stripe*. The symbols in the alphabet of the language are the still-pictures or snapshots to be strung together in chronological order. Given a finite set Φ of formulas, or fluents, a

symbol consists of a consistent subset of Φ, which non-exhaustively enumerates what holds true at a certain state.[2] Therefore, a situation is represented not just by the two states that mark its beginning or end, but by all its intermediate states as well. Here, we are finally given a real subatomar, internal perspective on a situational type, such that all temporal parts of the denoted situation are explicitly represented, and equally available for formal manipulation, while still kept together as one logical unit.

A suitable compositional device for stepwise construction of complex situational concepts is available in form of a regular operation *superposition* (&) over two languages (L and L′), by which Fernando supplements the usual regular constructs. Superposition performs componentwise alignment of strings of equal length and is realized model-theoretically as conjunction.

$$\mathrm{L} \,\&\, \mathrm{L}' = \bigcup_{k\geq 1}\{(\sigma_1 \cup \sigma'_1\ )\ ...\ (\sigma_k \cup \sigma'_k) \mid \sigma_1...\sigma_k \in L, \sigma'_1\ ...\ \sigma'_k \in L'\}$$

A simple example (by Fernando), of compositionally deriving the representation for the phrase "rain from dawn to dusk", should make clear the general line of thought, as presented so far ($\boxed{\ }$ stands for $\emptyset$-as-a-symbol, boxes replacing braces).

(4) $\boxed{\text{rain}}^{+}$ & $\boxed{\text{dawn}}\,\boxed{\ }^{+}$ & $\boxed{\ }^{+}\,\boxed{\text{dusk}} = \boxed{\text{rain, dawn}}\,\boxed{\text{rain}}^{*}\,\boxed{\text{rain, dusk}}$

Fernando's central idea for a definition of aspectual features is to formally base it on the symbols α and ω that start and finish a given language, respectively. A symbol σ *finishes* L if $\mathrm{L} \succeq \neg\sigma^{+}\sigma$ and σ *starts* L if $\mathrm{L} \succeq \sigma\neg\sigma^{+}$. *Negation* of symbols is defined in DeMorgan style by:

$$\neg\,\boxed{\ } = \Phi \text{ and } \neg\,\boxed{\phi_1,...,\phi_n} = \boxed{\neg\phi_1} + ... + \boxed{\neg\phi_n}$$

(writing + for non-deterministic choice). This enables a nice formal encoding of the idea of a situational type being initially or finally *bounded* or *unbounded*. If the condition α is immediately switched after the first stage an initial boundary is marked; if α is preserved the concept is initially unbounded. In the same way ω can be used to mark a final boundary, reading the string from right to left in that case. Aspectual features, according to Fernando, then just enumerate all the possibilities for a corresponding concept to be bounded or unbounded in that sense.

[2]For an exact and detailed definition of the underlying model see Fernando [11].

$$
\begin{array}{lcl}
\textit{telic}\ (\mathrm{L}) & = & \neg\omega(\mathrm{L})^{+}\ \Box \\
\textit{iter}\ (\mathrm{L}) & = & \Box\ \omega(\mathrm{L})^{+} \\
\textit{prog}\ (\mathrm{L}) & = & \Box\ \neg\alpha(\mathrm{L})^{+} \\
\textit{reten}\ (\mathrm{L}) & = & \alpha(\mathrm{L})^{+}\ \Box
\end{array}
$$

In order to express when a situational type falls under one or other of these abstract aspectual concepts, Fernando uses a pre-order *subsume* ($\succeq$), which intuitively compares two languages according to their informational content.

$\mathrm{L} \succeq \mathrm{L}'$ iff $\mathrm{L} \subseteq \mathrm{L}\ \&\ \mathrm{L}'$

A certain situational type L then falls under one of the four aspectual concepts β just in case $\mathrm{L} \succeq \beta(\mathrm{L})$.

Notably, on this perspective, the four classical aspectual classes are derivable as the set of logically possible cross-combinations of the four aspectual features as defined above. The corresponding properties of being initially or finally bounded, are marked by using a short binary code, with the first digit referring to the beginning, the second to the ending, and 1 and 0 indicating the presence or absence of a boundary, respectively. If we let a and o refer to the two boundary marking propositions we get the abstract characterizations on the very right. Notice how close those situational patterns are to the schemata drawn in Figure **??**, which were directly motivated by the empirical facts concerning aspectually shifted readings of temporal adverbials there.

state:	reten, iter	(0 0)	$\boxed{a,\ o}^{+}$
activity:	prog, iter	(1 0)	$\boxed{a,\ \neg o}\ \boxed{\neg a,\ o}^{+}$
achievement:	reten, telic	(0 1)	$\boxed{a,\ \neg o}^{+}\ \boxed{\neg a,\ o}$
accomplishment:	prog, telic	(1 1)	$\boxed{a,\ \neg o}\ \boxed{\neg a,\ \neg o}^{+}\ \boxed{\neg a,\ o}$

The following translations, which give formalizations within the framework of the initial examples (**??**) and (**??**), may serve as an illustration. (For the sake of abbreviation, $\neg a$ is suppressed in presence of o on the basis of obvious entailment relations.)

(5) a. $\Lambda(\textit{be quiet}) = \boxed{\text{be quiet}}^{+}$

b. $\Lambda(\textit{swim}) = \boxed{\neg\exists \mathrm{x} \neq \emptyset\ (\mathrm{swim(x)})}\ \boxed{\exists \mathrm{x} \neq \emptyset\ (\mathrm{swim(x)})}^{+}$

c. $\Lambda(\textit{arrive}) = \boxed{\neg(\text{be there})}^{+}\ \boxed{\text{be there}}$

d. $\Lambda(\textit{build a tower}) = \boxed{\neg\exists \mathrm{x} \leq \mathrm{t}\ (\mathrm{build(x)})}\ \boxed{\exists \mathrm{x} \leq \mathrm{t}\ (\mathrm{build(x)}),\ \neg\mathrm{build(t)}}^{+}\ \boxed{\mathrm{build(t)}}$

4 The Proposal: Supervaluations

Within the formalism introduced so far, the commonly assumed constraint on the interpretability of temporal adverbials reads as follows (with V representing a verbal phrase, and I an expression denoting a temporal interval):

> Λ(V *in* I) = {Λ(V) & Λ(I) if Λ(V) is telic; $\emptyset$ otherwise}
> Λ(V *for* I) = {Λ(V) & Λ(I) if Λ(V) is iter; $\emptyset$ otherwise}.

The aim of this section is to improve on that by giving room, within the semantic framework itself, for those kinds of adapted interpretations that actually occur, as shown by the initial examples. The approach to be offered will put the representational view (carried out in section 2) at work, as "(t)*he move from structures and their truth conditions to descriptions of structures and their truth conditions offers a uniform and natural way to* underspecify (...) *semantics*." (Muskens [22])

The logical heart of the proposal to be made here is *Supervaluation Theory*, originally introduced by van Fraassen [31] as a formal tool for handling *presupposition failure*. The more general theoretical aim of van Fraassen's approach was to account for a "third possibility" beside the classical valuations *Truth* and *False* in a way that preserves as much as possible from the classical framework. So, notably, while the supervaluationist denies the metalogical *Principle of Bivalence*, he still accepts the logical *Law of Excluded Middle* together with all other classical tautologies. The decisive difference between this approach and other three-valued logical systems is due to the idea of using *truth-value gaps* rather than a proper third value. Ordinary partial valuations are extended to supervaluations by considering the possible completions of a given model, that is the set of classical valuations such that all missing values get filled up in one way or the other. Take metavariable M to stand for partial models, M$'$ to range over all possible completions of M, and M* to be the *supermodel* of M, comprising M together with all its M$'$.

> A *supervaluation* based on M is a function that assigns *Truth* with respect to M* to a proposition ϕ just in case ϕ is classically true in all M$'$, *False* just in case it is false in all M$'$, and # (*gap*) otherwise.

That means, if a proposition ϕ has received supervalue # there are underlying, more precise models such that ϕ is true in some of them and false in others.

With this additional technical equipment available, let me now turn back to the problem of giving an appropriately flexible, but non-ambiguous formal characterization of the semantic contribution of temporal adverbials. The main task obviously consists in offering a proper semantics for the prepositions "in" and "for"

that accords with the overall aspectual semantic formalism rather than just stipulating ungrammaticality of the respective strings, as has standardly been done so far. Those semantic characterizations should effectively constrain the basic applications of the adverbials in the way commonly assumed, while at the same time allowing and triggering compositional adaption of sense via meaning shifts. The algorithm I am going to introduce proceeds in three steps, illustrated here firstly by means of a telic example ("build a tower *for an hour"), and afterwards an atelic example ("swim *in an hour"). The general lead-in will be the idea of formally treating aspectually sensitive temporal prepositions as some kind of *dynamic, structural presuppositions* with respect to the development of the truth value of a certain proposition over time.

As the *starting point*, I assume the representations of the meanings of the two temporal prepositions "in" and "for" under (**??**) and (**??**). These formalizations take into account the known preferences with respect to the aspectual type of the situational concept to be modified by encoding the properties *telic* and *iter* according to the formal definitions given in the previous section.

(6) a. $\Lambda(in) = \boxed{\neg o}^{+}\ \Box$

b. $\Lambda(for) = \Box\ \boxed{o}^{+}$

In the first, preparatory step of composition, the prepositions get combined via superposition with the nominal phrase "an hour", as done in (**??**) and (**??**).

(7) a. $\Lambda(for\ an\ hour) =$

$\Box\ \boxed{\text{O}}^{+}\ \&\ \boxed{\text{time(m)}}\ \Box^{+}\ \boxed{\text{time(n), hour(m,n)}} = \boxed{\text{time(m)}}\ \boxed{\text{O}}^{+}\ \boxed{\text{O, time(n), hour(m,n)}}$

b. $\Lambda(in\ an\ hour) =$

$\boxed{\neg\text{O}}^{+}\ \Box\ \&\ \boxed{\text{time(m)}}\ \Box^{+}\ \boxed{\text{time(n), hour(m,n)}} = \boxed{\neg\text{O, time(m)}}\ \boxed{\neg\text{O}}^{+}\ \boxed{\text{time(n), hour(m,n)}}$

Now, the adverbials are ready for modifying the situational concepts, whose abstract aspectual characterizations are given once more in (**??**) and (**??**). (Here, an activity is chosen as the atelic example, an accomplishment as the telic one. For states and achievements, though, the respective procedures would work in exact the same way.) The explanation will proceed with respect to the telic example first.

(8) a. $\Lambda(\text{V}^{\text{iter}}) = \boxed{a,\ \neg o}\ \boxed{\neg a,\ o}^{+}$

b. $\Lambda(\text{V}^{\text{tel}}) = \boxed{a,\ \neg o}\ \boxed{\neg a,\ \neg o}^{+}\ \boxed{\neg a,\ o}$

In its *first*, obligatory phase, the algorithm combines the representation of the temporal adverbial with the abstract characterization of the situational concept by means of *superposition*. If the aspectual type of the situational concept agrees with

the structural condition set by the preposition, the incorporation of prepositional meaning does not have any visible effect. The semantic material just combines normally via superposition, as can be seen in (**??**), and the algorithm finishes here.

(9) $\Lambda(\mathrm{V}^{\mathrm{tel}}$ *in an hour*$) = \boxed{a,\ \neg o,\ \mathrm{time(m)}}\ \boxed{\neg a,\ \neg o}^{+}\ \boxed{\neg a,\ o,\ \mathrm{time(n)},\ \mathrm{hour(m,n)}}$

However, in case of an aspectual clash between preposition and event description, combining the concepts leads to a contradiction at some predetermined position inside the complex situational type, as happens in (**??**). This formal accident can be traced back to the preposition and the situational type contributing different claims with respect to the truth-value of the proposition o, encoding the telicity feature.

(10) $\Lambda(\mathrm{V}^{\mathrm{tel}}$ **for an hour*$) = \boxed{a,\ \neg o,\ \mathrm{time(m)}}\ \boxed{\neg a,\ \underline{\neg o,\ o}}^{+}\ \boxed{\neg a,\ o,\ \mathrm{time(n)},\ \mathrm{hour(m,n)}}$

As these are the cases where interesting aspectual shifts occur, the real action starts here. In its *second* phase, the algorithm applies a *repairing* mechanism by assigning the supervalue # to the proposition that previously had received contradictory valuations. The result of this operation is shown in (**??**).

(11) $\Lambda(\mathrm{V}^{\mathrm{tel}}$ *#for an hour*$) = \boxed{a,\ \neg o,\ \mathit{time(m)}}\ \boxed{\neg a,\ \underline{\#o}}^{+}\ \boxed{\neg a,\ o,\ \mathit{time(n)},\ \mathit{hour(m,n)}}$

The general formal rule applied here is exactly the one standardly assumed for other cases of presupposition failure. That means, the meaning of a temporal preposition is thought of as some kind of dynamic, structural presupposition with respect to the development of the truth value of a certain proposition. Its semantic contribution is empty in case the verbal concept it combines with shows the right internal structure, but which induces a truth-value gap at a particular position inside the situational string whenever its structural constraint is not satisfied. In the latter case, the result of this semantic operation is a situational concept which is *underspecified* with respect to the *aspectual feature* telic (*#telic*).

As stated above, lacking a truth-value in the sense of supervaluationism, consists in the capacity in principle to be made precise in more than one way. That means, for the proposition o having been marked # in a supermodel M*, there are underlying models in M′ such that o is true in one of them but false in another. This *determination* of previously underspecified information in all possible directions, by grounding the freshly introduced supervalue # in the underlying classical models[3], is just what the algorithm is supposed to do in its *third*, last step. The

[3]The room that is left open for precision here is meant to comprise the single proposition o. That means, the valuations missing in the original partial model at the point when the truth-value gap is introduced are just completely left out. This is done so with the intention to avoid the algorithm having to rely unrealistically on maximally informative states.

two obvious outputs with respect to the telic example are spelled out in (**??**) and (**??**).

(12) a. $\Lambda^1(\mathrm{V}^{\mathrm{tel}}$ *for an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{\neg a,\ \underline{o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

b. $\Lambda^2(\mathrm{V}^{\mathrm{tel}}$ *for an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{\neg a,\ \underline{\neg o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

Interestingly, the move from the input concepts to these new, fully specified output concepts amounts to a strategy to save monotonicity of the overall interpretational process by allowing *reciprocal adaption* between preposition and situational concept.

This reintroduction of truth-values after a forced gap gives rise to a specific set of new regular languages. What situational concepts do those rebuilt structures encode? In (**??**) the result state description appears to have spread over the entire internal part of the expression. Under this perspective the preparatory phase was abstracted away, and the event culminates immediately after start. In consequence, the adverbial now gets interpreted as indicating the duration of the *result state* of the situation. Obviously, this is the first of the adapted readings we had found in connection with the modification of telic situational concepts by "for"-adverbials at the very beginning (compare Figure **??**). Under (**??**) this point gets further illustrated with the help of the familiar concrete example (in (**??**) and (**??**)).

(13) $\Lambda^1($*build a tower for an hour*$) =$

$\boxed{\neg\exists x \leq t\ (\text{build(x)}),\ \text{time(m)}}\ \boxed{\exists x \leq t\ (\text{build(x)}),\ \text{build(t)}}^{+}\ \boxed{\text{build(t)},\ \text{time(n)},\ \text{hour(m,n)}}$

In contrast, the second way to make precise the aspectually underspecified concept in (**??**) leads to the description in (**??**). Here, the preparatory phase makes up the whole inner part of the regular expression. Consequently, applying the temporal adverbial gives the description of an event that takes an hour to culminate. What we have here clearly amounts to the *preparatory phase* reading of the "for"-adverbial (Figure **??**). Again, (**??**) offers concrete illustration.

(14) $\Lambda^2($*build a tower for an hour*$) =$

$\boxed{\neg\exists x \leq t\ (\text{build(x)}),\ \text{time(m)}}\ \boxed{\exists x \leq t\ (\text{build(x)}),\ \neg\text{build(t)}}^{+}\ \boxed{\text{build(t)},\ \text{time(n)},\ \text{hour(m,n)}}$

Notice that the formal mechanism does in principal not serve to get rid of the *factivity entailment* for the result state here. While this seems plausible for examples like "grow old for many years", it is certainly not so for "read a book for a few minutes". I take this ambivalence as indicating that this question is not a matter of aspectual logical form, causing "hard" semantic inferences, but depends on background knowledge concerning default durations of certain kinds of events. Another argument for this strategy of keeping formal semantic and pragmatic mechanisms separate, despite the similarity of the aspectual effects they

may cause, has already been given in the first qualifying remark in the first section in face of examples like "hiccup all day". There, aspectual shifts were triggered in the absence of aspectual clashes solely on the basis of this kind of world knowledge. With respect to the above example, this would mean that in order to eventually strip off the result state, a second, pragmatic principle would have to get applied to the intermediate, semantic output gained here.

So far so good. But what about the *iterative* reading we found as the third possibility when looking at this kind of example at the very beginning? To derive this interpretation, let us take out one of the several different-sized strings encoded by the regular expression in (**??**), which, for instance, may look like this.

(15) $\Lambda'(\mathrm{V}^{\mathrm{tel}}$ *#for an hour)* =

$\boxed{a,\ \neg o,\ time(m)}\ \boxed{\neg a,\ \underline{\#o}}\ \boxed{\neg a,\ \underline{\#o}}\ \boxed{\neg a,\ \underline{\#o}}\ \boxed{\neg a,\ \underline{\#o}}\ \boxed{\neg a,\ o,\ time(n),\ hour(m,n)}$

Now, obviously, different classical valuations can be chosen for different states, leading, for instance, to the pattern under (**??**).

(16) $\Lambda^3(\mathrm{V}^{\mathrm{tel}}$ *#for an hour)* =

$\boxed{a,\ \neg o,\ time(m)}\ \boxed{\neg a,\ \underline{o}}\ \boxed{\neg a,\ \underline{\neg o}}\ \boxed{\neg a,\ \underline{o}}\ \boxed{\neg a,\ \underline{\neg o}}\ \boxed{\neg a,\ o,\ time(n),\ hour(m,n)}$

That means, preparatory phases freely alternate with result states, thereby forming a situational description which can only be interpreted as referring to a situation comprising several iterations of the original event. This complex situation as a whole becomes the attaching point for the temporal information carried by the adverbial. In (**??**) one possible such move is spelled out with respect to the concrete example. (As usual, entailment relations between the propositions a and o are taken into account.)

(17) Λ^3(*build a tower for an hour*) =

$\boxed{\neg\exists x \leq t\ (build(x)),\ time(m)}\ \boxed{build(t)}\ \boxed{\exists x \leq t\ (build(x)),\ \neg build(t)}\ \boxed{build(t)}$

... $\boxed{\exists x \leq t\ (build(x)),\ \neg build(t)}\ \boxed{build(t),\ time(n),\ hour(m,n)}$

Although we have derived all the possible interpretations of a "for"-adverbial when applied to a telic concept, the task of accounting for adapted readings of an "in"-adverbial modifying an atelic situational description has not been completed. A *preparatory phase* and a *boundary* reading is what we would wish the semantic mechanism to deliver here (Figure **??**). The following formulas are the result of applying the three steps of the shifting algorithm - superposition (**??**) and (**??**); reparation (**??**); determination (**??**) and (**??**) - for the atelic case.

(18) a. $\Lambda(\mathrm{V}^{\mathrm{iter}}$ *for an hour*) = $\boxed{a,\ \neg o,\ time(m)}\ \boxed{\neg a,\ o}^{+}\ \boxed{\neg a,\ o,\ time(n),\ hour(m,n)}$

b. $\Lambda(\mathrm{V}^{\mathrm{iter}}$ **in an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{\neg a,\ \underline{o},\ \underline{\neg o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

As before, in order to escape contradiction, in the second case (**??**) the algorithm proceeds by underspecifying the critical telicity information. The side effect of the truth-value gap spreading over from o to a in the atelic example in (**??**) is due to the fact that both propositions are generally negation variants of each other here (compare (**??**)).

(19) $\Lambda(\mathrm{V}^{\mathrm{iter}}$ *#in an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{\#a,\ \underline{\#o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

Then, fulfilling the third, determination step with respect to the above underspecified concept, leads to the following two regular languages.

(20) a. $\Lambda^{1}(\mathrm{V}^{\mathrm{iter}}$ *in an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{a,\ \underline{\neg o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

b. $\Lambda^{2}(\mathrm{V}^{\mathrm{iter}}$ *in an hour*$) = \boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{\neg a,\ \underline{o}}^{+}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

In (**??**) the start of the phase of activity is postponed to the very last symbol. On that basis, the temporal adverbial gets interpreted as specifying the duration of the respective pre-phase. In (**??**), on the other hand, the activity phase of the situation got spread over the entire real suffix of the regular expression. Therefore, the adverbial adds information concerning the temporal boundaries of the whole situation. So both known interpretational possibilities can straightforwardly be accounted for by the proposed formalism. Again, the concrete examples in (**??**) and (**??**) may help understanding.

(21) a. $\Lambda^{1}($*swim in an hour*$) =$

$\boxed{\neg\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)}),\ \text{time(m)}}\ \boxed{\neg\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)})}^{+}\ \boxed{\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)}),\ \text{time(n)},\ \text{hour(m,n)}}$

b. $\Lambda^{2}($*swim in an hour*$) =$

$\boxed{\neg\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)}),\ \text{time(m)}}\ \boxed{\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)})}^{+}\ \boxed{\exists \mathrm{x} \neq \emptyset\ (\text{swim(x)}),\ \text{time(n)},\ \text{hour(m,n)}}$

The formally possible third adaption variant, derived in exact parallel to the iterative interpretation gained for the previous, telic example, is not very prominent here and normally not discussed in the literature. But there are certainly special contexts in which this description may nevertheless apply (imagine some sort of interval training session, for instance). So there is no over-generation here. An abstract and a concrete version of such iterative interpretation of an "in"-adverbial modifying an atelic situational concept are given in (**??**) and (**??**)

(22) $\Lambda^{3}(\mathrm{V}^{\mathrm{iter}}$ *in an hour*$) =$

$\boxed{a,\ \neg o,\ \text{time(m)}}\ \boxed{a,\ \underline{\neg o}}\ \boxed{\neg a,\ \underline{o}}\ \boxed{a,\ \underline{\neg o}}\ \boxed{\neg a,\ o,\ \text{time(n)},\ \text{hour(m,n)}}$

(23) $\Lambda^3(\textit{swim in an hour}) =$

$\boxed{\neg\exists x \neq \emptyset\ (\text{swim}(x)),\ \text{time}(m)}$ $\boxed{\neg\exists x \neq \emptyset\ (\text{swim}(x))}$ $\boxed{\exists x \neq \emptyset\ (\text{swim}(x))}$ $\boxed{\neg\exists x \neq \emptyset\ (\text{swim}(x))}$

... $\boxed{\exists x \neq \emptyset\ (\text{swim}(x)),\ \text{time}(n),\ \text{hour}(m,n)}$

The aim of the semantic interpretation process has been achieved at this point. It was to make provision for the set of possible readings found in the cases under consideration in a fully compositional manner, i. e., only using lexical semantic entries and general rules for combining them. Now that this stage has been reached, further methods will have to apply in order to filter out the best actual candidate with the help of further contextual information and world knowledge.

Let me finish this section by adding a short, provisory remark on behalf of the aforementioned project of a cognitive semantics. When trying to explain the linguistic mechanism underlying these adaptations of meanings in terms of a more general cognitive principle, the following story seems to recommend itself as intuitively plausible. The rationale behind the move of introducing a truth-value gap in the decisive step of the algorithm may be seen as not passing judgement in face of equally probable but opposing evidence. In the course of determination, the ideal language user - instead of losing any information previously received - is trying to make the best out of the situation by developing different, coherent hypothetical interpretations separately. On the basis of additional incoming information, the space of possibilities will be diminished.

5 Conclusion: Aspectual Underspecification

The aim of this paper was to show how the meaning potential of temporal adverbials can be formally accounted for, and to give room, within the compositional semantic framework itself, for an efficient derivation and systematic explanation of the exact number and kinds of possible readings. This should be done in a way which leaves the general idea of a lexical encoding of aspectual situational classes intact, and saves and explains the applicability of the standard language internal testing procedure.

The critical discussion at the beginning of the paper pointed towards a new, dynamic, decompositional and representational view in event semantics. The starting point for a compositional semantic theory of aspectual meaning shifts was the idea of formally treating the lexical meanings of aspectually sensitive temporal prepositions as some kind of dynamic, structural presuppositions.

According to the proposal made, aspectual shifts consist in restructuring a situational concept from inside rather than in simple mappings from one atomic event to another. The two relevant factors - aspectual propriety and special ontological relatedness - which appeared independent from the point of view of static

event semantics, and which partly laid beyond the reach of any known compositional semantic treatment, thus naturally combine in one and the same simple derivational step.

The whole process is triggered by some kind of type conflict, as traditionally assumed, but gets now controlled by the introduction and consequent filling in of a truth-value gap. Literally, the meaning of a verbal phrase including an aspectual clash between temporal adverbial modifier and situational concept to be modified is an aspectually underspecified situational concept. The possible aspectually shifted readings then appear as the different ways of specifying it.

As opposed to what is the case in traditional theories of aspect shift, those possible ways of specifying are compositionally determined, i. e. by exclusive recurrence of semantic material already present in the enriched representation, and via application of the standardly assumed rule for cases of presupposition failure. Therefore, the semantic process in question is analysed here as entirely language internal.

Another interesting feature of the proposed algorithm when compared to the traditional approach seems to be that it is not the one-sided compliance of letting the verbal phrase possibly be type-changed by the adverbial, but rather the idea of allowing reciprocal adaptations that finally leaves us with the right set of predictions. Hereby, monotonicity of the overall interpretation process is preserved.

Last but not least, the procedure of systematically introducing underspecification as some kind of claimed ignorance in the presence of conflicting evidence, and of subsequently trying out all possible specifications separately, seems to be a plausible hypothesis about the rational strategies we really may use when adapting sense.

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