Assessing Parsimony in Models of Aspect

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Abstract

Though human beings are experts in the determination of aspectual relations, current models of Aspect lack principled parsimony. We show that even on a limited segment of language, determining aspectual interpretations seems to require much *ad hoc* information. Our suggestion is to give parsimony first priority. The model we present in this paper is limited in scope, but its complexity is bounded *in principle*.

Keywords: Temporal Aspect; Cognitive minimalism; Natural Language Processing.

Aspect and Parsimony

Human beings have strong intuitions about Aspect. For instance, though the two following sentences are syntactically well-formed, only the first one is semantically acceptable.

(1) She wants to eat up the cake in one minute.

(2) # She wants to eat up the cake for one minute.

These intuitions suggest that native speakers of a given language have a genuine *competence* concerning Aspect. Aspect combines different features, such as termination or repetition. It is tempting to consider this "aspectual competence" as consisting in a mere pattern-matching process. For instance, some incompatible features such as boundedness and unboundedness would be assigned to "to eat up the cake" and to "for one minute" respectively, making their combination illegal in (2). Unfortunately, no pure pattern-matching model of Aspect has been discovered yet. All models include computational components consisting in exceptions, type change (coercion) or context-dependent procedural rules. For instance, the sequence of instructions shown in Figure 1 has been proposed by Gosselin (1996) to describe the behavior of the French equivalent of 'in' + duration (as in example (1)).

(a) construct an interval [ct1, ct2]
(b) make it non-punctual (ct1 < ct2)
(c) make it coincide with the process interval
(d) make the process interval 'intrinsic'
(e) include it into the 'reference' interval

Figure 1: Instructions representing *en* + duration (after Gosselin,1996).

Another sequence of instructions is needed for 'in' + period (as in "in 2010"). Gosselin proposes a variety of "programs" like this one to account for aspectual words. Each step of these programs has several alternatives. For instance, Gosselin's model introduces four interval types that expand Reichenbach's (1947) reference point system; these intervals may coincide, overlap or be in various inclusion relations. The whole system produces many potential combinations, but only a few of them are useful to represent aspectual meanings.

The problem with computational models is that they may uncontrollably depart from parsimony. For instance, Gosselin's model sets no limit to the size of the instruction set that may be assigned to a given word combination.

The present paper has three related objectives. First, our aim is to highlight the necessity of limiting the complexity of models of Aspect, while making the distinction between actual and principled parsimony. Second, we will propose a small benchmark on which the parsimony of models of Aspects may be compared. Third, we will evaluate our own model in regard to this benchmark and discuss the results.

Principled *vs.* Actual Parsimony

Any model of Aspect must face the difficulty of describing a variety of sentence types that sometimes differ in minute details. Several authors tried to discover notions that prove useful to explain aspectual variation. The best known conceptual framework in this respect is probably Vendler's (1967) categorization of the lexical Aspect of verbs (state, activity, accomplishment, achievement). Certain notions such as dynamicity or perfectivity have been explored by various authors (*e.g.* Comrie, 1976; Gosselin, 1996; Smith, 1997). Elucidating the way human beings process Aspect would be easy if the only problem was to check the compatibility of fixed features attached to lexical entries or to predicates, such as 'activity', 'dynamicity' or 'telicity'. Unfortunately, mere feature unification proves insufficient to predict the aspectual acceptability of sentences. For instance, 'drink a glass of wine' is expected to clash with 'for three years', because the former is perfective and the latter is durative. The sentence:

(3) She drank a glass of wine for three years

is however acceptable with an iterative interpretation ('She drank a glass of wine everyday for three years'). The sentence is 'saved' dynamically, thanks to a phenomenon called 'coercion' (de Swart, 1998) or 'conflict resolution' (Gosselin, 1996): iteration transforms a perfective situation ('drink a glass of wine') into an imperfective repeated situation that matches 'for three years'.

Though the introduction of procedural components like coercion seems inevitable, it introduces a risk. If the language in which procedures are expressed is too rich, the model is no longer constraining. When it reaches the expressivity of a Turing machine, the model can express any computation. It becomes purely descriptive and loses any explanatory power. An explanatory model must be able to restrict the range of possibilities.

A possible answer is that though the procedural power of models of Aspect is often not limited *in principle*, it may be parsimonious *in fact*. Procedural rules may be kept simple, even if they are expressed in a rich meta-language. For instance, although no upper bound is set *in principle* to the variety and the size of its procedures, Gosselin's model could be claimed to be *actually* parsimonious (but this actual parsimony has yet to be established).

The form of parsimony we are referring to corresponds to a *minimum description length* (MDL) principle. It measures the static length of procedures, not the number of procedural steps executed at processing time. For instance, despite the fact that a recursive procedure may require time and memory resources to be executed up to a certain depth, it may constitute a parsimonious model if it can be expressed in a compact way. The question is to know whether we can achieve reasonably parsimonious models of Aspect. Several requirements must be met.

- Principled parsimony
    - Fixed number of possible features
    - Upper bound for procedure length
- Actual parsimony
    - Compact procedures (*i.e.* of small static length)
    - No or few exceptions

Though parsimony is of course a primary concern when dealing with Aspect, authors are sometimes more sensitive to exceptions than to the potential computational power of their models. As a consequence, few attempts have been made to demonstrate the principled parsimony of models. The purpose of the present paper is to show that a (partial) model of Aspect can be parsimonious *in principle*.

A Benchmark for Models of Aspect

Processing Aspect is a baffling task. We can observe a variety of interpretations with only a limited set of examples (Table 1). We consider examples in French because aspectual relations are less constrained by the chosen lexicon than in English. *This example set represents already a challenge for most models of Aspect*. Of course, any model can be adapted to cover the examples, but with the risk of adding *ad hoc* knowledge. The examples correspond to a simple pattern (most of them translate straightforwardly in English):

<*Elle*> <pp> <verb> <compl.> <preposition > <durative period>

where *elle* means 'she' and <pp> means 'present perfect'. For instance:

(4) *Elle a mangé du gâteau pendant une minute*
(she has been eating cake for one minute)

This sentence is coded as Efrom–F–D–M in Table 1. We consider only two verbs:

- E: *manger* (to eat) with the following meanings:
    - Efrom: to eat from something (to eat cake)
    - Eup: to eat something up (to eat the cake)
    - Elunch: to have lunch
    - Ebite: to take a bite
- S: *ronfler* (to snore)

Complements for *manger* may be:

- F: *du gâteau* (cake, from the cake)
- T: *le gâteau* (the cake)
- (void) no complement.

Only two prepositions are considered:

- I: *en* (≈ in)
- D: *pendant* (for, during)

Periods can be:

- M: *une minute* (one minute)
- S: *le spectacle* (the show)
- 2 : *2010*

Table 1: Set of sentences.

Sentence				*Interpretation*		
verb	*co.*	*prep.*	*period*	*Corresp.*	*rep.*	*pred.*
Efrom	F	I	M	after		vp
Efrom	F	I	2	slice		vp
Efrom	F	D	M	cover		vpp
Efrom	F	D	S	slice		vp
Efrom	F	D	S	cover		vpp
Eup	T	I	M	cover		vpp
Eup	T	I	M	after		vp
Eup	T	I	2	slice		vp
Eup	T	D	M	#	#	#
Eup	T	D	S	slice		vp
Elunch		I	M	cover		vpp
Elunch/bite		I	M	after		vp
Elunch/bite		I	M	after (?)	vp	vpr
Elunch/bite		I	2	slice		vp
Elunch/bite		I	2	slice (?)	vp	vpr
Elunch		D	M	#	#	#
Ebite		D	M	cover	vp	vpp
Elunch/bite		D	S	slice		vp
Ebite		D	S	cover	vp	vpp
Ebite		D	S	slice (?)	vp	vpr
Snore		I	M	after		vp
Snore		I	2	slice		vp
Snore		D	M	cover		vp
Snore		D	S	cover		vpp
Snore		D	S	slice		vp

Table 1 lists all syntactically admissible combinations of these words. The verb *manger* (to eat) can take various aspectual forms. With no complement, it may be perfective (= to have lunch) or imperfective (to snack, to nibble). The complement ('the cake' *vs.* 'cake') controls perfectivity. The preposition *pendant* corresponds to 'for' when used with actual duration ("one minute"); it corresponds to 'during' when used with a definite situation ("during the show"). The temporal meaning of *en* corresponds to 'in', but is slightly more restricted: "I'll leave in three minutes" translates into "*je pars* <u>*dans*</u> *trois minutes*".

Table 1 shows all admissible aspectual interpretations for each sentence (last three columns). The first interpretation (column 'correspondence') has three possible values.

- cover: the situation holds for the whole period. For instance, "to be eating cake for one minute" (*manger du gâteau pendant une minute*).
- slice: the situation holds during a portion of the period. For instance, "to eat (up) the cake during the show" (*manger le gâteau pendant le spectacle*).
- after: the situation holds just after the period is over. For instance: "to eat cake in one minute" (*manger du gâteau en une minute*).

The latter interpretation (sometimes called inchoative) is not straightforward in French with these examples, but it is nevertheless possible (*e.g.* in a context with a child who does not want to eat). It is more obvious with other verbs, as in "she confessed in one minute" (*elle a avoué en une minute*), which has a clear inchoative interpretation.

The column called 'repetition' indicates that the situation corresponding to the verb phrase (vp) is repeated.

The last column, called 'predication', indicates when a phrase *must* be predicated. Predication here means that the phrase carries the *attitude*. Attitudes are at the interface with relevance; they may be epistemic (unexpectedness, constraint violation) or epithymic (wanted or unwanted) (Dessalles, 2008). For our purpose here, we only need to consider that predication correlates with attitudes, and therefore with negation: the situation is contrasted with its opposite. For instance, the last line of Table 1 refers to a situation in which "she snored (at some point) during the show" (*elle a ronflé pendant le spectacle*). For this interpretation to be valid, "snore" must carry the attitude (*e.g.* snoring was unexpected or unwanted, by opposition with not-snoring, which is the norm). By contrast, the durative interpretation of the same sentence: "she snored during the (whole) show" this time requires that the attitude be carried by the whole verb phrase (vpp), *i.e.* vp with prepositional complement ("snore during the show"). Now, the opposition is not 'snore' *vs.* 'not-snore', but "snore during the whole show" *vs.* any incompatible alternative (*e.g.* be interested at some points by the show, snore for a shorter/longer time). Note that the vp-predication (*e.g.* snoring is forbidden or scandalous) prevents from considering the durative interpretation.

Predication is a crucial component of aspectual relations. As Table 1 illustrates, predication controls inchoative (after) and slice interpretations. The first example of the Table 1: "she ate cake in (= after) one minute" is only valid if "eating cake" can take the attitude (*e.g.* it was unexpected, wanted or forbidden). The same holds for the second example ("she ate cake in 2010").

Note that Table 1 allows for repeat-slice or repeat-after combinations. For instance, "she ate during the show" (*elle a mangé pendant le spectacle*) can be understood as "she (repeatedly) snacked at some point during the show, a fact that must have some relevance (*e.g.* being unexpected, or shocking, or (un)wanted). This complication (repetition + predication) leads to borderline admissibility, indicated by question marks in Table 1.

Table 1 represents a challenge for any model of Aspect. It is not clear whether any classical model of Aspect can provide all admissible interpretations of these examples (and no more) without *ad hoc* addition. The challenge is not only to predict the two dozens of cases listed in the table. It is also to account for them with a simple computation.

Any data set can be explained by merely listing the data. We can compute the complexity of this "null-model". For each word combination, one has to decide among four possible correspondences: 'cover', 'slice', 'after' and incorrect (#); one has also to determine whether the situation is repeated or not, and which phrase is predicated. Each word combination therefore generates 16 possible interpretations, among which the model must determine those that are correct. This requires 16 bits, as each combination may be correct or not. For the simple sentence pattern we are using, the null-model requires 16×V×P×A bits to predict all interpretations, where V is the number of verbs, P the number of prepositions and A the number of periods. If we take the four nuances in the meaning of *manger* into account, this makes 400 bits to account for Table 1 (after syntactic filtering). This number would grow uncontrollably if we increase the size of the vocabulary. The challenge is to find a simple model that can predict interpretations with much less information. If a model explains only part of the data, each exception must be included in the complexity of the model.

A Minimalist Model of Aspect

Models of Aspect offer only partial explanations of aspectual relations, since Aspect depends on actual languages and, within a language, on a variety of specific words or morphemes, including tense, prepositions, adverbs, verbs or adjectives. In English, the present perfect, the preposition 'in', the adverb 'still', the verb 'to stop' or the adjective 'ancient' impose aspectual constraints. The grail of research on Aspect would be to find a language-independent model that would predict aspectual meaning based on minimal lexical specification for a limited set of words.

Purely linguistic knowledge is however insufficient to predict aspectual correctness, as illustrated by the following example.

(5) # She bought this book three minutes after her trip to China.

Assuming a trip to China would last typically for a week, this sentence is semantically odd. It is however acceptable if we replace 'minutes' by 'days' or 'week'. Conversely, example (3) is no longer correct with 'seconds' instead of 'years'. Knowledge about situations in the 'world' is therefore necessary to process Aspect. We must have some language-independent means to know that drinking a glass of wine takes seconds or minutes, but not years, or that eating a crumb takes much less time than eating a big cake. Any model of Aspect must be able to interface with this kind of perceptual device to know whether durations are compatible.

whether the situation is considered from the outside (**f**) or from the inside (**g**). This notion of viewpoint matches similar binary attributes used by other authors (Smith, 1991; Filip, 1999; Ghadakpour, 2003). The French preposition *en* ('in') is associated with an **f**, whereas *pendant* ('for' or 'during') is associated with a **g**.

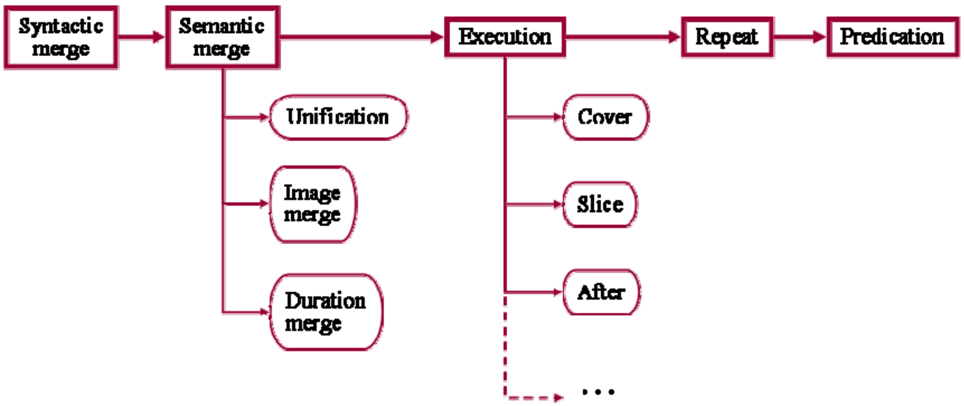

Figure 2: Architecture of the model

On the other hand, much of aspectual processing seems to be independent from perception. The unacceptability of (2) is not due to the inability to form an image. Special words like 'in' or 'during' play a crucial role. Models may explain aspectual data by postulating complex behavior directed by those words. For instance, the procedure shown in Figure 1 has been imagined to control the behavior of *en* + duration (Gosselin, 1996). Note that the procedure does not suffice to produce inchoative interpretations, and that *en* + 2010 would require yet additional instructions. Can we think of simpler models of Aspect?

Architecture of the model

The model presented in this section is an attempt to answer this question (Munch, 2013). Though it is still far from processing the whole gamut of aspectual relations, it is sufficient to correctly predict the most important ones, including those used in Table 1. Figure 2 shows the architecture of the model. The procedural components are fixed. They synchronize with syntactic processing, as each syntactic combination triggers an attempt to combine meanings (semantic merge). The semantic merge gives rise to new structures which are then executed. Lastly, two optional operations are performed: repetition and predication.

Aspectual Information Structures

Contrary to most other models, the model of Figure 2 operates on fixed-size structures, called Aspectual Information Structures (AIS) (Munch, 2013).

Figure 3 lists the content of an AIS. The three first items are binary attributes. The *viewpoint* attribute may take two exclusive values, **f** (figure) or **g** (ground). It indicates

- Viewpoint (**f** or **g**)
- Determination (**d** or **u**)
- Multiplicity (**s** or **m**)
- Operation
- Image
- Duration

Figure 3: Aspectual Information Structure

Determination is another binary switch. It opposes situations that have a unique temporal location, such as 'the show', from periods with no definite locations, such as 'one minute'.

Multiplicity is a binary flag that holds repetition in memory. It is well-known that aspectual processing is blind to the frequency of repetition. In example (3), the periodicity could be every day or once a year (at each birthday, say). A binary flag is therefore sufficient for keeping track of repetition.

The *operation* slot refers to a procedure. Contrary to other models (see Figure 1), only a limited set of fixed procedures is allowed. The examples of Table 1 are processed with only one procedure: *simultaneity*.

The *image* slot is meant to be a reference to a perceptual structure. It is necessary to trigger image synthesis (Kosslyn, 1994). We do not use it in the current version of the model.

The *duration* slot holds a numerical value that represents a typical duration value (it could have been included in *image*). Duration is used during merge to check that the two merged structures have compatible durations (*i.e.* that they differ by no more than one order of magnitude). This is necessary to avoid the kind of duration incompatibility illustrated by example (5).

Table 2 lists relevant AIS elements for a few words. Typical durations are given by their logarithmic values in seconds ($60 \approx 10^{1.8}$).

Table 2: A few AIS.

	viewp.	*det.*	*duration*	*operation*
en (in)	**f**	**–**	**–**	simult
pendant (for)	**g**	**–**	**–**	simult
eat (lunch)	–	–	3.5	
minute	–	**u**	1.8	
the	–	**d**	**–**	
show	–	–	3.8	
2010	–	**d**	7.5	
"during the show"	**g**	**–**	3.8	

Unification

Unification is triggered when two words or phrases (head and complement) are merged by syntax. All attributes in the two AIS are matched by compatibility. The last line of Table 2 shows how unification can lead to new AIS when semantic merge has been performed (note that determination is not set, as explained below).

Unification alone explains the contrast between examples (1) and (2). "To eat up the cake" is an **f**. It matches with the **f** of "in one minute", but it clashes with the **g** of "for one minute". Viewpoint incompatibility also explains why a durative interpretation of "She ate during the show" cannot be based on the meaning "to have lunch" (Elunch), where the lunch would last for the whole show, but requires the repetitive version of Ebite (see Table 1).

Determination is essential to control for the possibility of slicing and of inchoativity. Only determined periods such as "2010" or "the show" can be sliced. Conversely, inchoativity requires an undetermined period, such as "one minute".

Duration compatibility explains why "she ate during the show" (line Ebite–D–S in Table 1) accepts a repetitive interpretation with the meaning Ebite, but not with the meaning Elunch (there is not enough time to have multiple meals during the show).

Procedural components

As Figure 2 suggests, the procedural component of our model is not limited to unification. There is an *execution* phase in which certain operations can be performed. The parsimony of the model relies on the fact that there can be only a few operations. To account for the examples of Table 1, we only need one operation: *simult* (simultaneity). A few other operations are needed to account for other aspectual relations, such as *after-now*, which is used to process the temporal meaning of *dans* in French.

Simult is executed when words like *en* or *pendant* are merged with their complement (see Table 2). It requires a durative complement (*i.e.* with a numerical duration). It has three possible outputs (Figure 2).

- *Cover*.
- *Slice*, if the complement is determined.
- *After* (inchoativity), if the complement is a not-determined figure.

The *determination* flag of the complement is forgotten. The *duration* of the output for *slice* and *after* is set to a non numerical value, **nil**.

Figure 2 shows two additional procedural components. The first one is *repetition*. Only verb phrases that correspond to figures (**f**) can be repeated.

The last procedural component is *predication*. Only phrases can be predicated. Its effect is to set viewpoint to **f**, determination to **d**, multiplicity to **s** (singular) and duration to **nil**. Only one predication is allowed per sentence.

Implementation

The model is currently implemented in Prolog[1]. Syntactic processing is achieved using a small DCG grammar. All procedural combinations are explored through backtracking. For instance, *repetition* and *predication* have no effect at first call, and act on the current AIS only at backtracking time.

One originality (and strong point) of the model is that all operations beyond *merge* are unary (monadic). Most models use binary (dyadic) operations, like the operation shown in Figure 1. One operand is the duration given as complement, and the other one is the process (which should not yet be available from the syntax). By contrast, our operations are strictly unary. For instance, when "during the show" is processed, *simult* is executed and does not wait for the vp. "During the show" gives two alternative AIS:

- viewp = **g /** det **= – /** duration = 3.8 / image = cover
- viewp = **– /** det = **d** / duration = **nil** / image = slice

Similarly, and contrary to classical models, inchoativity is achieved by transforming the period, not the situation given by the verb. "In one minute" produces the following AIS:

- viewp = **f /** det **= – /** duration = 1.8 / image = cover
- viewp = **f /** det = **d** / duration = **nil** / image = after

Outputs of the procedural component, such as 'cover', 'slice' or 'after', should be further processed by a perceptual module (not implemented).

Discussion

The preceding model has been designed to be as parsimonious as possible. As it stands, it predicts all the examples of Table 1. Moreover, it does not produce any incorrect output that it would not signal as such.

Parsimony relies on several characteristics.

- Fixed-size structures. Contrary to most models, AIS have a bounded size. They are not recursive (an AIS does not contain another AIS), unlike for instance HPSG structures.

[1] Available at www.dessalles.fr/Data/MD_Cogsci2014.zip

- Amnesia. Many models are procedurally monotonic, which means that the structures they process can only grow in size and complexity during processing, becoming unrealistic for large inputs (Ghadakpour, 2003). The semantic merge operator is ‘amnesic’, which means that the input AIS are lost. It makes one single fixed-size AIS from two AIS. Our model is therefore procedurally non-monotonic.
- Procedural components such as *simult* or *repetition* are given in advance. They belong to the model and are not attached to the lexicon (unlike what is shown in Figure 1).

This last point is crucial. The symbolic information contained in the AIS is bounded by 6 bits (one bit for each of the three binary flags: *viewpoint*, *determination*, *multiplicity*, plus three bits if we allow for eight operations). This means that the model requires a fixed amount of information corresponding to its procedures (Figure 2), plus 6 bits times the size of the aspectual vocabulary (‘in’, ‘during’, ‘minute’, ‘since’…). This is of course much less than the null-model, which requires 16 bits, not per word, but per *word combination*!

This upper bound makes our model parsimonious *in principle* and not only *in fact. To our knowledge, it is the first computational model of Aspect that has this property.* Thanks to this property, not only the descriptive power of the model, but also its *explanatory* power, can be considered. Models with procedures directly attached to the lexicon (as shown in Figure 1) can hardly be falsified, as it is always possible to fit the data by adding new instructions. Our model refuses this easy option.

Admittedly, part of the information needed to process Aspect is not included in the above assessment of the model’s parsimony. Information about typical durations, the polysemy of a verb like ‘to eat’ (to have lunch, to take a bite) or the fact that there is only one lunch per day, is not counted. In line with (Moens & Steedman, 1988), we consider that this information belongs to other cognitive modules.

An original aspect of the model is the introduction of the predicative component. To our view, it is inevitable if we want to account for many of the examples of Table 1. Consider the following examples.

(6) I want to drink alcohol next year.
(7) I want to drink alcohol for ten minutes next year.

(6) makes sense for instance if I am a Muslim and if drinking alcohol is unexpected for me. “Drink alcohol” becomes a binary fact (to drink or not to drink). This binary aspect is incompatible with duration. This is why (7) may seem odd. For (7) to be acceptable, the Muslim context is of no help. One has to imagine that drinking alcohol for that duration is unexpected. This means that predication must concern the whole verb phrase (vpp) and not the vp (‘drink alcohol’) alone. As the model predicts, the latter is excluded, because **nil** duration would not match the durativity of “ten minutes”.

Conclusion

We tried to show that explaining aspectual relations with a restricted set of principles is a hard task, even for a limited segment of language. We introduced a set of sentences that can be used as a benchmark for models of Aspect. We suggested that though many models can be claimed to have bounded *actual* complexity, their complexity is not bounded *in principle*. We introduced our own model and showed that its complexity has the property of being bounded in principle.

Our approach to aspectual processing has several original features, such as the use of unary operations and the formal use of predication.

We did not demonstrate that our approach can scale up to deal with the whole gamut of aspectual phenomena. For this, a lot more investigation work is still required. At this point, our purpose was rather to show that a very limited corpus of examples is already sufficient to assess the parsimony of models. This study can be understood as an invitation to evaluate the performance (in terms of principled and actual parsimony) of alternative models against a given set of sentences, as the one listed in Table 1.

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References

Comrie, B. (1976). *Aspect.* Cambridge Univ. Press.

de Swart, H. (1998). Aspect shift and coercion. *Natural Language & Linguistic Theory*, *16* (2), 347-385.

Dessalles, J-L. (2008). *La pertinence et ses origines cognitives - Nouvelles théories.* Paris: Hermes-Science.

Filip, H. (1999). *Aspect, eventuality types and noun phrase semantics.* New York: Routledge.

Ghadakpour, L. (2003). *Le système conceptuel, à l’interface entre le langage, le raisonnement et l’espace qualitatif: vers un modèle de représentations éphémères*. Paris: Thèse de doctorat, Ecole Polytechnique.

Gosselin, L. (1996). La sémantique de la temporalité en français - Modèle calculatoire et cognitif. Duculot.

Kosslyn, S. M. (1994). *Image and brain.* Cambridge (MA): MIT Press, ed. 1999.

Moens, M. & Steedman, M. (1998). Temporal ontology and temporal reference. *Comp. Linguisitics*, *14* (2), 15-28.

Munch, D. (2013). *Un modèle dynamique et parcimonieux du traitement automatisé de l’aspect dans les langues naturelles*. Paris: PhD dissertation, Telecom ParisTech 2013-ENST-0058.

Reichenbach, H. (1947). *Elements of symbolic logic.* New York: Macmillan Co.

Smith, C. S. (1997). *The Parameter of Aspect.* Dordrecht: Kluwer.

Vendler, Z. (1967). *Linguistics in Philosophy.* Ithaca, NY: Cornell University Press.