

## PhD 2 – objectives and work package plan

### 1. Objective

In the short description of the spreading-activation memory model, we presented the memory model focusing on syntactic dependencies and simple syntactic features like [+/-*Subject*]. However, it is obvious that not only syntax has to rely on memory. An obvious next step to extend the current models of retrieval, often considered in psycholinguistics, is to investigate how semantic knowledge is stored and recalled. This is needed even for a good model of syntactic parsing, since syntactic parsing goes hand in hand with incremental interpretation and semantic information affects and steers parsing (Altmann et al., 1985, Trueswell et al., 1994, Steedman, 2000). Including semantic knowledge allows models to go beyond sentence levels and be ready to analyze discourses. As is known, discourses are structured and have to conform to discourse rules (Kamp, 1984, Kamp and Reyle, 1993). Furthermore various dependencies are not clause-bound, rather, they are sensitive to discourse structures, and thus, going beyond the sentence-level has the additional benefit of making the investigation of these dependencies possible.

One example of a discourse dependency is the resolution of pronouns. Pronouns can pick up antecedents across clauses and the resolution is clearly sensitive to discourse rules. For example, even though both (1a) and (1b) have a noun phrase object in the first clause, only (1a) allows this noun phrase object to serve as an antecedent to the pronoun. The quantifier in the scope of negation cannot fulfill this role, since noun phrases in the scope of negation introduce discourse referents that are not accessible beyond the scope of negation.

(1a) The professor has a son. In the past years, he had to work during all the holidays.

(1b) The professor does not have a son. In the past years, he had to work during all the holidays.

Models of memory structures should be able to deal with discourse dependencies and should be able to operate with discourse rules that limit the resolution of dependencies.

The objective for this sub-project, then, is to construct and investigate memory structures of semantic knowledge. Such memory structures should allow the model to go beyond sentence-level phenomena and syntactic dependencies and to study the incremental interpretation of a discourse.

### 2. Work package 2: beyond syntax

The study of memory in language is currently predominantly focused on the retrieval of syntactic dependencies. Independently of the research into the properties of memory in language, there are numerous investigations into the characteristics of discourse, which uncovered how discourses are structured, what role the structures play in discourse coherence, what is the role of discourse connectors on reading, how constructions of situation models affect online measures (Frank et al., 2003, Kehler et al., 2008, Drenhaus et al., 2016, Venhuizen et al., 2019).

WP2 investigates how the memory structures play a role in discourse by connecting the study of memory retrieval and discourse structures and coherence.

First, we should note that at least some discourse phenomena which are prime candidates to be treated as cases of memory retrieval follow the predictions of memory models. For example, in Winkowski et al. (submitted) it has been shown that the resolution of anaphoric presuppositions, i.e., presuppositions that have to be resolved anaphorically, is affected by the distance to the antecedent. Comparing (2a) and (2b), it was observed that the spillover region of the presupposition trigger *too* is read faster when the distance between the antecedent and the trigger is short, (2a), than when it is extended, (2b). The contrast is compatible with a general position that some kind of memory recall plays a role here. It can be interpreted under the spreading-activation model (in which memory chunks carrying the same feature as the target chunk *i* interfere and lower the activation of the chunk *i*) as follows: assuming that any predicate could potentially be the antecedent for the presupposition resolution of *too*, predicates other the actual antecedent serve as distractors and since there are more distractors in (2b) than (2a), the slowdown is expected.

(2a) Anne came first in her race. She burst into tears. Caroline won too, setting the lap record.

(2b) Anne came first in her race. She raised her hands. She screamed out loud. She burst into tears. Caroline won too, setting the lap record.

It has also been shown that discourse structures play a role in anaphoric resolutions. Such an effect has been observed on pronoun resolution (Kush et al., Schmitz et al., Parker, 2022) and anaphoric presupposition resolution, among others (Chen and Husband, 2018).

The first goal of WP2 is to collect more direct experimental evidence showing that spreading-activation memory models should help us understand the construction of discourse and the storing of discourse information in memory. The second goal is to see whether once we go beyond the most obvious cases that could be modeled as retrieval (e.g., anaphora) we still observe the pattern expected from the theory of spreading-activation memory models (e.g., the role of distance, and the effect of discourse structuring).

The standard methodology to investigate memory structures is to study reading time patterns and reaction times. More concretely, it is expected that PhD2 will master and make extensive use of methods such as self-paced reading studies and eye-tracking-while-reading experiments. These can be supplied with other experimental methods, like a maze task, visual world paradigm and speeded acceptability judgements.

**Below, we discuss several directions that the project will take. This is a plan and the actual research might diverge from it. Exact details will be worked out in collaboration with PhD2.**

### ***WP2a: resolutions in discourse and meaning spaces***

Resolving anaphoric relations and presuppositions in discourse shows properties one would expect if these were cases of dependency and had to be resolved by memory recall. In WP2a, we collect an unambiguous evidence that directly targets the predictions of the spreading-activation memory model.

We leverage the observation that memory models should show a close affinity to multidimensional spaces of distributional semantic models (see also PhD1 - details). We construct experiments in which it is not the distance in words that is manipulated for presuppositions and anaphora, rather we manipulate the distance in meaning spaces. Let us illustrate the idea with presuppositions. Presuppositional triggers such as *again* signal anaphoricity to the antecedent. Given that recall has to happen to satisfy this anaphoricity, we expect that its properties could be investigated in spreading-activation memory models. This in turn means that the antecedent predicate should receive spreading activation from the cues of the predicate appearing with *again*. The ease of retrieval should increase or decrease depending on how close this meaning of the antecedent is to the meaning of the predicate and how close the distractor (a predicate specifying an action of another participant) is to the meaning of the antecedent. Finally, let us note that one of the basic assumptions of the spreading-activation memory model is that if the distractor is close to the antecedent in the memory space, it should cause interference, which affects recall (recall gets worse) and retrieval time (more time is needed to retrieve information). Consider (3) with this background.

(3a) Anne and Mary trained yesterday. Anne ran five miles. Meanwhile, Mary danced. At the end of the day, Anne decided to go running again.

(3b) Anne and Mary trained yesterday. Anne ran five miles. Meanwhile, Mary jogged. At the end of the day, Anne decided to go running again.

In this example, we expect that in (3a) the retrieval will be easier and faster than in (3b). This is because in (3b) the distractor (*Mary*) *jogged* is closer in the memory structure to the antecedent (*Anne*) *ran*, hence causing higher interference, compared to the distractor (*Mary*) *danced* in (3a).

The predictions will be investigated in a reading experiment (e.g., eye-tracking-while reading study or a self-paced reading study) and we expect slower reading times due to semantic interference in the resolution of anaphoric presupposition. The adverb *again* is, obviously, not the only element that signals presuppositions. The experiment will be followed up by investigations into other cases of presupposition, such as presuppositions triggered by *too* and anaphora.

It is intended that the findings in WP2a supplement the findings in WP1 (done by PhD1), which investigates the properties of the spreading-activation model *within* a sentence. In conjunction with WP1, WP2 will provide direct evidence that the proposed spreading-activation model of memory structures plays a role beyond sentences and standard cases, namely, in the resolution of discourse dependencies. It will also give us a novel evidence for the analysis of anaphoric presuppositions: it targets the question whether or not these should be treated as cases of retrieval, in line with other retrieval phenomena.

### ***WP2b: going beyond anaphoric relations in a discourse***

WP2a considers phenomena for which it is quite uncontroversial that they receive their interpretation through some means of memory retrieval. After all, anaphoric presuppositions are often analyzed as requiring retrieval in semantic and discourse literature (van der Sandt, 1992, among others) and even

accounts that do not explicitly talk about retrieval would have to assume that some kind of information recall has to take place, hence they would be compatible with the proposed analysis (Saebo, 2004). WP2b goes beyond these uncontroversial cases. It investigates whether the memory model proposed here can and should be applied wider, to cases that are not normally seen as involving retrieval but which clearly require some kind of information recall in discourse interpretations.

Discourse anomalies are primary candidates to be studied in WP2b. As an illustration, consider (4), from Stewart et al. (2009). This short text was tested in two versions, italicized and divided by the slash / in (4). The only difference between the two conditions is the spatial location of the main character, introduced in the first sentence. The story specified that the character was standing either at the side of the stage or in the centre of the stage. The latter option turned out to be incompatible with some upcoming information. This incompatibility led to processing difficulties observed by an increase in reading times of the last sentence.

(11) Carly stood *at the side/centre* of the stage to start the next song. This was her favourite song to perform. It was a difficult song and she was proud that she could sing it well. As it was her favourite, she always saved it for the end of a show. After the first verse she moved to the centre of the stage where she would stay until the song ended.

Obviously, such discourse anomalies on discourse coherence can only be detectable if readers retain or recall the relevant information. The hypothesis investigated in WP2b is that this recall takes place from the same memory structures assumed throughout, i.e., a spreading-activation memory model. This hypothesis will be studied in WP2b by manipulating the distance in length (e.g., the amount of words) between the point at which the discourse anomaly can be detected and the information that causes the anomaly, and by manipulating other factors discussed above: distances in meaning spaces and distances between the anomalous elements and potential (that is, non-anomalous) distractors. The issue will be investigated in a reading study. Aside from eye-tracking-while-reading experiment, other methods will be considered to investigate the robustness of the effect: speeded acceptability judgements or EEG data collection are primary candidates. In the latter case, a possibility is to construct a listening experiment, to confirm the finding using a different modality (cf. Meyer et al., 2012).

Suppose we find support for the spreading-activation model of memory in this case. What did we learn then? This finding goes beyond the conclusion that, to put it bluntly, some other phenomena apart from anaphoric presuppositions show a pattern compatible with standard cases of memory retrieval. Rather, findings in WP2b would tell us how people structure and store information collected in discourse. For example, consider the case in (3). If we discover that detecting discourse anomalies relies on a spreading-activation model, e.g., detecting anomalies is affected by distractors and positions on meaning spaces, it follows that memory structures in which discourse information has been stored and from which it is retrieved in detecting the anomaly can be approximated using this memory model. Ultimately, the findings of WP2b will not just tell us how discourse anomalies are detected, but they will be revealing for our understanding how discourse information in general is stored in memory and recalled from it.

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