Experimental Entailments: The Case of Spatial Prepositions

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Abstract
In this paper we present an experimental study on native speakers' access to lexical relations among spatial relations. Our main focus is a still poorly understood domain: the lexical relations that hold between (pairs of) directional spatial prepositions (*from*, *to*) and locative prepositions (*at*). Two broad families of proposals exist in the literature. One family suggests that the members of these two classes of prepositions are connected via the entailment relation. Another family suggests that the overlap relation connects directional and locative prepositions. These two proposals differ with respect to the predictions they make on how speakers can accept and logically connect sentences that include such pairs of prepositions. We offer an experimental study, based on a variant of the Truth-Value Judgment Task, which aims to adjudicate which family of proposals makes the correct predictions. Then, we discuss the theoretical import of the results.

Keywords: Spatial Prepositions; Entailment; Experimental Semantics; Lexical relations; Truth Value Judgement Task

1. Introduction

Many recent works in experimental semantics have investigated in detail the interpretation of *Spatial Prepositions* (Feist 2008; Feist and Gentner 2012; Coventry, Tenbrink and Bateman 2009; Coventry and Mix 2010). Two core questions have guided this research. A first question is how speakers access the senses of Spatial Prepositions (henceforth: SPs), and adjudicate whether or not they describe an extra-linguistic context. A second question is whether speakers can access the *lexical relations* that hold among SPs in a given context. For instance, Coventry and Garrod (2004: ch.2-3) investigated whether speakers would accept (1)-(2) as adequate descriptions of different pictures showing a basket containing an apple with different degrees of inclusion:

(1) The apple is on the basket
(2) The apple is in the basket

Participants usually deemed both sentences as adequate descriptions of most pictures, although their preferences varied from picture to

picture. While (1) was preferred when used to describe pictures that displayed a partial degree of inclusion, (2) was preferred when used to describe a total degree of inclusion. Since these two sentences only differ with respect to the SP they include, the results seem to suggest that speakers can access two aspects of SPs and their senses. A first aspect is their basic lexical sense, and how this sense can match a certain scenario. While *in* seems to highlight the fact that the basket partially contains the apple, *on* seems to highlight the fact that the basket also supports the apple. A second aspect includes lexical relations among SPs. That is, examples (1)-(2) suggest that the senses of *in* and *on* are lexically related, since they can be used to describe the same states of affairs, but with different levels of efficacy.

One empirical void that emerges when one looks beyond examples such as (1)-(2) pertains to our knowledge of which lexical relations speakers can access when SPs are involved. The nature of this void can be made precise via a discussion of SPs and their senses' properties. SPs are usually distinguished between *locative* SPs (*in*, *on* and *at*) and *directional* SPs (*from* and *to*) (Cresswell 1978; Jackendoff 1983, 1990; Parsons 1990; Fong 1997; Zwarts 2005). The senses of both directional and locative SPs correspond to a spatial relation defined between a landmark object, or *ground*, and a located entity, or *figure* (Talmy 1978; 2000). However, these classes of SPs differ when a second layer of meaning is involved, and which captures the temporal/consequential status of the spatial relation at stake. To discuss this difference, consider the sentences in (3)-(5):

(3) Harlock went to the park
(4) Harlock came from the park
(5) Harlock was at the park

Examples (3)-(4) show that the sense of a directional SP captures the figure's position as changing over time. The sense of the SP phrase *to the park* captures the changing position of the figure (Harlock), which starts from an implicit location, and reaches the park after moving. The sense of the SP phrase *from the park* captures the inverse direction of movement, but has the same underlying "dynamic" nature. The sense of a locative SP lacks this sense of change: the figure's position is understood to be stable over time, as *at the park* in (5) does. This

distinction is not absolute: most SPs belonging to either type can alsohave complementary readings in certain sentences (*going* or *sitting across the street*: Cresswell 1978; Zwarts 2005). However, this distinction adequately captures the fact that SPs can be distinguished into two clearly distinct, although flexible, sub-classes.

Since SPs can be divided into sub-types, a logical possibility is that certain lexical relations can be defined over the members of each class. In the case of *in* and *on*, and the sentences in (1)-(2), it is generally assumed that their senses are related via a relation that we dub as the *overlap relation*. We define the overlap relation as a relation holding between two complex senses, when there is one part of their senses that is shared. If this is the case, then the shared "sub-sense" can be used to describe an extra-linguistic context (Nam 1995; Evans and Tyler 2003). A clear and uncontroversial case in which the overlap relation holds between two SPs, and the sentence that contains them, is that of *in* and *on* in (1)-(2), as these two SPs share a core "locational" sense.

However, a more controversial debate exists when SPs belonging to the two sub-types are involved, for instance *to*, *from* and *at* in (3)-(5). The nature of the debate pertains to the *type* of relation at stake. At least two families of proposals can be identified within this debate. Some proposals suggest that the senses of locative and directional SPs also stand in the overlap relation. Hence, *at* captures Harlock's position at the end of an event of motion directed *to the park*. Similarly, *at* captures Harlock's position at the beginning of an event of motion originating *from the park* (Jackendoff 1983; Zwarts and Winter 2000). Thus, the senses of *to* and *at* overlap when they refer to an interval of time at which they identify the figure being located "at" the ground.

Other proposals, instead, suggest that *to* and *at*, *from* and *at* and similar pairs of directional and locative SPs, stand in the *entailment relation*.[1] We define the the entailment relation as a relation holding

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[1] For the readers interested in the logical aspects of our discussion we offer standard definitions of entailment and overlap relations. We say that S' entails S if and only if we can derive the sense p of S from the sense p' of S' (Landman 1991: ch. 1; Hodges 2001: ch. 2). We represent this fact as $p'=I(S')$: the interpretation of a sentence in a model is the sense p (a proposition). Formally, we have: $(S'{\Rightarrow}S){\Leftrightarrow}(p'=I(S') \Rightarrow p=I(S))$. We then say that S' overlaps with S if an only if a there is part p'' of the sense p of S that is also a part of the sense p' of S'. Formally, we have: $(S'{\circ}S){\Leftrightarrow}(((p'=I(S')){\cap}(p=I(S))=p''{\neq}\varnothing)$.

between two complex senses, when from a first sense the second sense can be derived as a "part" of this first sense. In this case, the sense of *to* captures the "path" that Harlock covered, when he went in direction of the park. The sense of *at*, instead, captures the position of Harlock *after* he moved in the park's direction, and as a consequence of moving along this direction. Unlike in the case of the overlap relation, the related intervals of time are distinct, rather than (partly) overlapping. Thus, the overlap and entailment relations offer a different analysis of the lexical relation(s) that hold between between *to* and *at*, and *from* and *at.* Interestingly, there seems to be no empirical studies that have tried to adjudicate which relation captures speakers' intuition about the relations between (3)-(5) and (4)-(5), hence between pairs of locatives and directional SPs and their senses.

The goal of this paper is to answer this empirical question by offering experimental evidence that adjudicates between the two relations, and the theories that support an account based on either relation. For this purpose, we organize the paper as follows: We offer a broader overview of the theoretical and experimental background in the rest of the introduction, present the experiment in section 2, and our conclusions in section 3.

1.1. Theoretical background

The goal of this section is two-fold. A first goal is to offer an overview of the literature on the semantic properties of SPs. A second goal is to motivate why the study of the lexical entailment relations among directional and locative SPs is theoretically and experimentally important.[2] Before we start, we make more precise the nature of the relations that we aim to investigate. Thus, we say that if these relations between sentences hold, when a single lexical item allows the formation of a minimal pair, then a *lexical entailment* or *lexical overlap* relation holds between these lexical items (Murphy 2010: ch.3).[3] In our

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[2] We leave aside *syntactic* matters concerning SPs. We invite the reader to consult recent works on this topic, for further discussion (Asbury 2008; Cinque and Rizzi 2010; Levinson and Wilkins 2006).

[3] A definition of the lexical entailment relation is: $(lex(S')\Rightarrow lex(S))\Leftrightarrow(p'=I(lex(S'))\Rightarrow p=I(lex(S)))$. A definition of the lexical overlap relation is: $(lex'(S')\circ lex(S))\Leftrightarrow(p'=I(lex(S'))\curvearrowright(p=I(lex(S))=p''\neq\varnothing)$. In

discussion, we concentrate on these two specific relations, thus dropping the qualifying term "lexical".

The literature on the semantic of SPs can be divided into two broad theoretical approaches, which we loosely label as the "conceptual" and the "model-theoretic" approaches. Conceptual approaches can be further split into two broad types of approaches. One is the "conceptual semantics" type (Jackendoff 1983, 1990; van der Zee 2000; cf. also Verkuyl and Zwarts, 1992; Zwarts and Verkuyl, 1994). The other type consists of a series of works afferring to, or within the "Cognitive Linguistics" approach (Herskovits 1986; Beitel, Gibbs and Sanders 2001; Eschenbach *et al.* 2000; Lakoff 1987; Evans and Tyler 2001, 2003, 2004; Evans 2006, 2010, 2013). Although the two families of approaches differ with respect to their starting assumptions, they both converge on the analysis of the lexical relations that hold among SPs.

We make precise these assumptions by starting with the conceptual semantics analysis. In this analysis, it is assumed that SPs can be divided into two syntactic and semantic "layers". A first layer is that of PATH functions, or the relations between figure and ground. Different types of relations can be defined, either denoting directed movement ("goal" for *to*, "source" for *from*) or location ("state", for *at*). These relations are in turn mediated via the PLACE function, a 1-place function that defines the precise position of the figure with respect to the ground (an internal portion for *in*). The sense differences and relations among SPs are reduced to differences in the specific values for these two functions. For instance, *to*, *from* and *at* share an underlying PLACE function as part of their senses, but while *to and* from also include a dynamic PATH function, *at* includes a static one. While *to* and *from* denote the position of the figure as it changes over time, which is "at" the ground during one specific interval of time, *at* lacks this dimension of change.

Cognitive Linguistics approaches, and other approaches with a closely related perspective, propose a different theoretical stance. These frameworks assume that SPs can be highly polysemous. So, the possibility that the specific senses of SPs stand in the overlap relation is a reflection of the polysemous nature of each SP. If two SPs, such as *in* and *on*, are both polysemous, then some of these senses can be indeed

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words, the lexical entailment relation holds when the sense of a lexical item includes the sense of another lexical item. The lexical overlap relation holds when the two senses share a "part" of this sense, but differ otherwise.

"shared" (cf. Herskovits 1986 about *in*, *at* and *on*). Similarly, their polysemous nature creates a possibility that the sense of one SP can entail that of another SP. For instance, the central sense of *to* captures the position of the figure as first changing over time, then as coinciding with the ground (Herskovits 1986; Evans 2006). The "ideal" sense of *at* is restricted to this latter relation, with no reference to any changes of position for the figure. Thus, the sense of *to* entails, or includes, that of *at*. A similar reasoning holds for *from*, *modulo* the inverse "flow" of change.

Once we have discussed these two types of conceptual approaches, we can shift our focus to model-theoretic approaches. These proposals usually make two key assumptions. First, SPs denote a 3-place relation that holds between a figure, a ground and a set of implicit[4] discourse referents.[5] Second, these implicit discourse referents correspond to spatio-temporal entities, which represent the location in which the figure is located with respect to the ground. Thus, the sense of a directional SP, for instance *to*, can denote a path that a moving figure covers over time with respect to the ground. Instead, the sense of a locative SP such as *at*, *in* or *on* can denote the set of possible locations that a figure occupies, without any change involved.

Model-Theoretic proposals usually differ on the fine-grained analysis of the spatial content of SPs. For instance, some proposals offer a mereological account, based on the "part-of" relation (Keenan and Faltz 1985; Bierwisch 1988; Wunderlich 1991, 1993; Nam 1995; Link 1998; Kracht 2002, 2004, 2008; Maillat 2001, 2003). Other proposals use a Euclidean model of space, often based on the notion of "vector" (Zwarts 1997, 2010; Zwarts and Winter, 2000; Bohnemeyer 2012). A third family of proposals focuses on the causal/temporal relations between events as implicit referents. Thus, these proposals remain "neutral" on specific spatial assumptions (Parsons 1990; Fong 1997; Kratzer 2003,

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[4] Implicit referents can only be explicitly referred to if *optional* syntactic elements (for instance, the indexical *here*) occur in a sentence; hence the label "implicit". See Landman (2000: ch.1) for discussion.

[5] Discourse referents are defined, in frameworks such as *Discourse Representation Theory,* as logical counterparts of extra-linguistic entities (Kamp, van Genabith and Reyle 2011). A useful metaphor is that of discourse referents acting as "pegs" or "folders" that represent the information we convey about the entities we talk about in discourse.

2007; Zwarts 2005, 2008; Gehrke 2008; Ramchand 2008; Ursini 2013, 2015a, b, c; Ursini & Akagi 2013d, e). All proposals, however, share one assumption: that a part of the sense of SPs captures the "structure" of this set of implicit referents.

Although a discussion of the formal aspects of these theories would take us too far afield, a key difference is how these proposals capture the the semantic relation between directional and locative SPs, such as *to* and *at*. In "Euclidean" approaches, the focus on the spatial dimension of SPs' senses determines which relations among senses can hold. For instance, according to Zwarts and Winter (2000: 191-195), the sense of *to* corresponds to the indicized set of vectors or *path* that the moving figure covers during an interval of time. The sense of *at*, instead, corresponds to a set of non-indicized vectors (a *region*), each indicating a possible position of the figure as close to the ground. Thus, *to* and *at* can overlap in their senses, since there can be an interval of time at which a moving figure (in this case, Harlock) is going "to" the ground (in this case, the park), while also being "at" the ground.

In mereological and event-based models, on the other hand, the lexical relation between *to* and *at* is explicitly modelled via the entailment relation. For instance, Parsons (1990: 76-82) suggests that sentence (4) describes the event that comes into being (the boy being at the park), as a consequence of the event described in (3) ceasing to exist (the boy going to the park). In other words, the sense of *to* includes that of *at*, since *at* identifies a "sub-event" of the related events that *to* identifies. Thus, these proposals offer predictions different than the geometric ones, with respect to the relation between directional and locative pairs of SPs.

This precise overview on the semantic literature about SPs and their lexical relations highlights one conceptual tension that exists on which relations among SPs can hold. In frameworks such as conceptual semantics and "geometric" model-theoretic semantics, the overlap relation seems to be the principal, if not the exclusive relation that can hold between SPs. In cognitive semantics and "event" model-theoretic frameworks, both overlap and entailment relations can hold among SPs and the sentences they are part of, although the exact relation at stake depends on the specific senses of the involved SPs. Despite the fact that these proposals are quite different with respect to the assumptions they start from, they seem to converge on their predictions about lexical

relations among locative SPs. If we take pairs of locative SPs, such as *in* and *on*, all four families of proposals would predict that they overlap in sense.

These proposals do differ, however, when they make predictions about the lexical relations that hold among pairs of directional and locative SPs, such as *to* and *at*. While Conceptual and geometric proposals also suggest that the overlap relation holds in this case as well, cognitive and event proposals suggest that the entailment relation represents how *to* and *at* (hence (3) and (5)), but also *from* and *at* (hence (4) and (5)) are lexically related. Accordingly, in the next question we address whether experimental studies have offered data that shed light on which analysis is more appropriate, for both types of relations.

1.2. Experimental Background
The goal of this section is to review experimental studies that have investigated the interpretation of SPs, in particular those works that have investigated sense relations among SPs.

One key aspect of the experimental literature on the interpretation of SPs and their sense relations is an almost exclusive focus on the sub-type of locative SPs. One such example includes the wealth of works within the "Functional Geometric Framework" (FGF: Coventry 1998, 1999, 2003; Coventry et al., 1994; Coventry and Garrod 2004; Coventry *et al* 2009). FGF is based on the assumption that the meanings of spatial SPs can involve a complex combination of geometric, functional, and mechanical dimensions of meaning. A consequence of this "multi-dimensional" approach is that SPs' senses can overlap, especially when they are matched against an extra-linguistic context. One example involves pairs of locative SPs such as *in* and *on*, as discussed via examples (1)-(2). Other works such as Coventry, Prat-Sala and Richards (2001) also tested pairs of sentences including *above* and *over*, and *under* and *below*. In this study, participants were asked to rate four sentences with respect to how accurately they described pictures of a Viking who held a shield above his head. The shield was shown to protect the Viking against the rain, and was inclined at different angles in each picture. Participants (N=36) were asked to evaluate the appropriateness of the sentences in (6)-(9) via a *Likert scale* questionnaire, with values ranging from 1 (completely unacceptable) to 7 (completely acceptable):

(6) The shield is *above* the Viking
(7) The shield is *over* the Viking
(8) The Viking is *under* the shield
(9) The Viking is *below* the shield

The results were as follows. Participants found (6) and *above* more appropriate when pictures showed a rain-less scenario; on the other hand, they found (7) and *over* more appropriate in rain-filled scenarios. The parallel pattern was found for for *under* and *below* (8)-(9). At the same time, median acceptance rates were fairly high for all scenarios (*n>5.60*). This and other similar results offer support for the view that the senses of locative SPs are connected via the overlap relation, since they can describe the same scenarios with varying degrees of accuracy. Other works on locative SPs offer similar findings, although they start from different assumptions (Feist 2000, 2002, 2004, 2006, 2008, 2009; Feist and Gentner 2002, 2003, 2012, Vandeloise 1994, 2005, 2010). Thus, the assumption that the overlap relation holds among locative SPs seems empirically adequate.

Once we shift our focus to directional SPs, and the relation between locative and directional SPs, the dearth of empirical evidence turns out to be conspicuous. Some elicitation works have investigated the production of directional SPs to describe scenarios in which a figure moved in the direction of the ground. For instance, participants were asked to describe a ball being kicked into a box. In describing this scenario, they would mostly produce *into* (Papafragou, Massey and Gleitman 2002; Lakusta and Landau 2005, 2012; Papafragou 2010). However, these studies did not investigate lexical relations among directional SPs; they only focused on investigating speakers' use of their basic senses. A partial exception exists in recent studies that have investigated the interpretation of *at* and *to* in adults, and the acquisition of these senses in children (Ursini & Akagi 2013a, b, c respectively). Although these studies hint at the possibility that such relations could be accessed by native speakers when they interpret sentences containing these SPs, they do not offer crucial empirical evidence shedding light on these matters.

Other works have investigated the production of directional SPs in "narrative" scenarios, known as "frog where are you?" tasks (Slobin 1996, 2004; Stringer 2005, 2006, 2012). These studies investigated how adults and children described the adventures of a boy looking for his

frog. These adventures involve text-less pictures in which the boy moved through several locations, by going into and then out of a forest. These studies found that participants usually connected each "path" to one event/interval of time. This is a principle sometimes known as the "unique vector constraint" (Bohnemeyer 2003: 94-96; Bohnemeyer *et al.* 2010). Importantly, however, the precise nature of the semantic connections between these events was not addressed. This was the case, since speakers were not explicitly invited to produce descriptions of the *relations* between these events and the paths to which they corresponded.

Overall, the experimental evidence we reviewed so far seems to remain silent on which lexical relations holds between directional and locative SPs. A picture exists for locative and, to a lesser extent, directional SPs: locative SPs seem to be connected via the overlap relation, as well as directional SPs. Hence, we still do not know whether the entailment or the overlap relation underlies speakers' understanding of the relation between *to* and *at*, *from* and *at*. We address this question in the next section.

2. The Experiment
This section presents an experimental study that investigated our experimental question about SPs and their lexical entailments.

2.1.Method
2.1.1 Participants
23 undergraduate participants from the main author's department of psychology took part in the experiment. These participants received course credit as a reward for attendance.

2.1.2. Materials
The experiment involved one power-point presentation, which was used to narrate three stories that participants had to carefully observe. Participants were also given an information sheet presenting an overview of the task, a consent form that offered an ethics statement, and an answer sheet for the test questions. Before each experiment's session, participants were instructed on how to offer their answers, and asked to sign the consent form and information sheet. All participants complied

and signed the relevant forms. More information about the content of the presentation is offered in the "procedure" section.

2.1.3. Design

The experiment involved a variant of the Truth-Value Judgment task (henceforth: TVJ task: Crain and Thornton, 1999). In this experimental paradigm, "truth" is understood as the ability of a sentence to accurately describe the facts in a certain extra-linguistic context. A standard variant of the TVJ task involves a scenario in which certain events occur. For instance, five deer compete to reach a forest, but must jump over a given lake to reach this forest. One deer cannot complete the task, as it trips against the fence and falls. One experiment controls a puppet that narrates the story, then offers question (10) to the participants:

(10) Has every deer gone to the forest?

Participants who can access the interpretation of the underlying declarative sentence will likely answer "no" (Crain and Thorrnton 1999: ch 15). In this story, this sentence is false, as it does not correspond to the described events. If a participant answers "yes" instead, one can infer that the participant still cannot access the intended, adult-like interpretation of this sentence. The one conducting the experiment can then offer a follow-up question ("What happened?"), which allows for testing whether the participant's understanding of the events was accurate. One important aspect of TVJ tasks is that they are designed in such a way that both "yes" and "no" answers are plausible as final answers. This condition is known as the *Condition of Plausible Dissent* (henceforth: CPD) (Meroni *et al*. 2006). In this case, a "yes" answer is plausible, because at some point in the story all five deer were likely to reach the forest. Once the last deer tripped and fell into the lake, the "no" answer became plausible, as well as true. Thus, a participant would answer a non-trivial question, since he would be allowed to choose between two equally plausible answers, but only one of them would be true in the context.

We now present the details of our experiment. The changes from the standard TVJ task were as follows. Each experimental session involved a power-point presentation which depicted three stories involving several

fictional characters. Each slide was accompanied by text consisting of two or three sentences depicting the events occurring in the story. The researcher read the text aloud to ensure that all participants knew the nature of the events depicted in the slides.

Before the story, a brief introduction offered an explanation of the answering procedure. This introduction presented the five main characters in the stories and the character who was going to offer the questions, called "Mr. Little Bears". Mr. Little Bears was described as an amnesiac teddy bear who watched the stories with the participants. Because of his memory problem, he had to offer some questions at the end of each story. Participants were required to answer the questions on an answer sheet, and write their follow-up answer afterwards.

One further change involved the structure of stories. Since the TVJ task is aimed at testing one experimental hypothesis, as the interpretation of the sentence underlying one test question, it does not directly lend itself to test lexical relations. Since lexical relations involve two lexical items and the sentences they occur in, they can be tested if at least two questions are presented, based on distinct events. For this purpose, the design of the stories involved the distinction between "sub-stories" describing distinct, but logically related, events. We spell out the exact details regarding the sub-stories in the next section, when we present the full procedure.

Our last change involved the design of the stories. As we planned to test which lexical relations between SPs hold, we devised stories in which a "yes" answer was the expected answer. We thus diverged from standard TVJ tasks, in which scenarios and answers requiring a "no" answer are the standard form of design. Our reason for making this choice was simple. Experiments testing complex inferential tasks may involve a serious cognitive load, which can affect the participants' answers (Rips 1994: ch.3). For instance, in a standard TVJ task the participants first compute under which conditions the underlying declarative sentence is true. Then, they compute that the declarative is false in that scenario, thus the only accurate answer is "no". Although these tasks are not particularly challenging for adults, other tasks that involve further inferences may overload participants' ability to compute a possible answer (Wason's tasks, sequential choices). Thus, participants may offer random answers, just to complete the task (Stenning and van Lambalgen 2008: ch. 4).

To avoid these confounding effects in our experiment, we chose to design a set-up in which "yes" answers corresponded to sentences accurately describing the stories described. Our goal was to reduce the putative cognitive load for participants, as participants had to answer more than one question per story. Since we designed these stories to also meet CPD, our design granted that participants could equally answer "yes" or a "no" on grounds of plausibility. We discuss the exact import of these design choices in the next section.

2.2. Procedure

The procedure was as follows. The presentation involved three distinct stories. The first story was designed to test which lexical relation participants accepted as holding between *to* and *at*. The third story, instead, tested the relation that participants accepted as holding between *from* and *at*. The second story acted as filler and did not test any relevant hypothesis, so that participants would not recognize the linguistic patterns under evaluation. Each story involved 5 different characters, taken from the "Thomas the tank engine" line of toys. These characters were presented as "tank engines", so that the participants would easily be able to track their collective identity during the stories and answer the questions afterwards. Mr. Little Bears, in his role as the "question-maker", was also presented in the general introduction.

The first story included five characters called Thomas, Percy, Rosie, Mighty Mac and Spencer. In this story, the five characters woke up for a new day of intense work. Their daily task was to deliver a cargo of fresh vegetables to Harold the Helicopter, the owner of a farm. Each character stopped at a location called "shower tank" to shower, before delivering their cargo successfully. Spencer and Thomas spent more time at the shower tank, as they forgot what their initial goal was. They however recalled at a later time, and reached the farm. This specific sub-event granted that the CPD was respected: by this point of the story, some but not all the tank engines went to the farm. At a later point, when Spencer and Thomas fullfilled their duties, all the engines went to the farm.

A second event was described when all the engines reached the farm. Harold the helicopter asked the engines if they would stay over for lunch. One engine, Rosie, declined the offer but she decided to accept when Harold insisted. This aspect of the event also granted that the CPD was

respected, since most but not all engines had breakfast before Rosie joined. Thus, by the end of the first story two distinct events were realized: the engines reached the farm and ate some food while being there. Since both events were described in one continuous story, no explicit mention of the eating event occurring after the "going to" event was made. We made this choice to avoid the participants' bias towards either, considering the two events were partially co-terminous, or rigidly ordered. These two possibilities, and with them the possibility that participants could consider either the overlap or the entailment relation as holding between *to* and *at*, were equally available. After the first story Mr. Little Bears appeared, and offered the following consecutive questions:

(11) a. "This is a nice story! Alas, I don't remember one thing: Have all the tank engines gone *to* the farm?"

   b. "My humble apologies. I also don't remember one more thing: Have all the tank engines eaten lunch *at* the farm?"

   c. "Final question, just to be sure! What happened in the story?"

Some words of clarification on the sense of the questions are due. A standard assumption is that the definite description the tank engines denotes the maximal plural referent in the denotation of tank engines, taken as a "group" (Link 1998: ch.1; Chierchia 1998). A complex predicate such as have gone to the farm, when combined with the tank engines, denotes an event in which this group reaches the farm; the semantic contribution of all grants that this relation is distributed to each referent that is part of this plural referent (Brisson 1998, 2003). Thus the use of all granted that speakers evaluated the truth of each sentence in context by evaluating whether each engine (Thomas, Percy, Rosie, Mighty Mac and Spencer) went to the farm and ate there. Given our discussion on the senses of to and at, the predicted answers for the first two questions were "yes" answers.

The third question was a follow-up question. The follow-up question had the goal of eliciting speakers to describe what happened in the "macro-story". This question invited speakers to explain if and how the

two events, and their respective spatial relations, were connected. Participants would thus offer an explicit answer on which lexical relation between *to* and *at* they would entertain, provided that they would offer "yes" as an answer to both questions. For this question, our predictions were slightly more complex. If participants would have described the events using temporal/causal connections, expressing a stricter order of events, then they accessed the lexical entailment relation. If participants would have described these events using temporal/causal connectives not expressing temporal/causal order, then they accessed the lexical overlap relation. Examples of critical lexical items in the follow-up descriptions were *after*, *then*, *because* for the entailment relation; *while*, *and* or *also* for the overlap relation. Thus, participants were asked not only to evaluate whether the senses of *to* and *at* matched the events described, but also to explicitly state which lexical relation they accessed.

After the first story was completed, the participants observed the filler story. This story depicted the engines going back home and playing football, with the final question being about the engines who scored a goal. The third story was set on the second day of work and involved new tank engines, barring Thomas. This change of characters was aimed at avoiding that the speakers' answers would be based on the events and characters they recalled from the first story. On the second day, the engines had to deliver the weekly mail to various locations in their village, Sodor. Importantly, the story began by explaining how the engines (Diesel 10, Duncan, Emily, James, Thomas) played a card game at the station, their home, before going out to deliver mail. Thus, this story also depicted two distinct events. Emily and Duncan spent too much time in the shower and risked missing the game, but were able to join at a later time. Hence, the CPD was respected for this event. The engines went on to distribute the mail, with Diesel 10 being tempted not to deliver a book package, and changing his mind after he felt guilty. Thus, the CPD condition was respected for this event as well. After the engines delivered the last mail, Mr. Little Bears appeared again to ask the three questions in (12):

(12) a. "This is a nice story! Alas, I don't remember one thing: Have all the tank engines started their work from the station?"

b. "My humble apologies. I also don't remember one more thing: Have all the tank engines played a card game at the station?"

c. "Final question, just to be sure! What happened in the story?"

For this story, we also predicted that participants would answer "yes" to both the first and second questions, given our discussion about the senses of from and at. For the follow-up question, the predictions that we had for the first story would apply to this story, too. Thus, we would predict that the choice of logical connectives in describing the events that occurred in the story would reveal which lexical relation speakers accessed in this scenario.

2.3. Results and Discussion

The results were as follows. 22 out of 23 participants offered "yes" answers to our questions in (10a-b), (11a-b). One participant offered a "not sure" answer to the second question for each story ("*at*"-question). The answer was written on the answer sheet, directly. The participant motivated this *impromptu* choice by explaining that it was too hard to recall what happened in the story. In fact, the participant did not offer any answers for both questions (10c) and (11c). We thus discarded these answers from the total count, and speculate that our choice of designing a less demanding task turned out to be useful, as only one participant experienced a cognitive load problem. Overall, 100% of the answers (22/22) were according to the predictions. If we take a confidence interval of 5% as the possibility participants answered correctly by chance, this result is in part skewed, although not in a statistically significant way. This result invites the conclusion that participants could access the senses of *to*, *from* and *at* as per predictions; hence, their answers to the follow-up questions evidenced which lexical relation they accessed.

The follow-up answers showed that speakers followed certain specific patterns in assessing these relations. In the first story, most participants defended their answer by observing that the eating event occurred after the "going to" event (12/22, 54.5%). The other speakers

suggested that a perhaps stronger causal relation was involved. Some suggested that the tank engines were eating at the farm because they went there (5/22, 22.7%). Others suggested that even stronger relations between the described events held (consequently, as a consequence of, therefore 3/22, 13.6%). Two participants offer less stringent explanations, motivating that one event and the other event occurred at similar time (one event and then the other, for one speaker). While these two answers support the overlap relation, the other answers support the entailment relations. More generally, 20/22 answers support the entailment relation (90.8%), while 2/22 answers support the overlap relation (9.2%). These results are consistent with the hypothesis that speakers accept that the entailment relation holds between *to* and *at*, rather than the overlap relation.[6]

The answers for the second story provided similar but not identical results. In addition, the answers broadly supporting the entailment relation were 20 out of 22. Entailment-supporting answers included the logical temporal prepositions before, then, successively, after ("the engines started after showering", participant n. 14). Only three participants used prepositions capturing logical connections, such as consequently. Two participants used and to describe the relation between the events of showering and starting, thus offering support for the overlap relation (2/22, 9.2%). We would like to suggest that the subtle difference in distribution of anwers between the first and second follow-up answers still support the hypothesis that speakers access the entailment relation. There is a subtle qualitative difference between temporally consecutive and causal relations, although both types of relations define events as not overlapping in time and/or cause, and being distinct. Consequently, the spatial relations that hold when these events hold can also be taken to be distinct, although logically related. This is why we consider the entailment relation to hold in these cases.

Overall, we think that both results on the follow-up questions, combined with the results on the yes-no questions, support the hypothesis that speakers access the entailment relation, as holding between directional and locative SPs. In turn, these results lend support

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[6] If we assume that speakers accept either the entailment or the overlap relation, then their answers should invariably converge to one side (100% of entailment relation-supporting answers). A χ^2 test revealed that this was indeed the case for the entailment relation ($\chi^2 = 1.04$, *p<.60, df=1*).

to two types of proposals on the lexical relations among SPs: cognitive and "event" semantics proposals. This is the case, since these proposals suggest that when directional and locative SPs are involved, their senses are (or can be) connected via the entailment relation. The "Euclidean" and cognitive semantic proposals, on the other hand, do not find support in our result, since these proposals suggest that only the overlap relation holds among SPs. We note, once more, that these proposals start from different assumptions; for instance, event semantics approaches do not place entailment relations within a broader theory of polysemy, as cognitive approaches do. Nevertheless, our results suggest that, at least in their common predictions, these proposals seem on the right track. At the same time, these results are consistent with previous results on the interpretation of *at* and *to*, as discussed in section 1.2 (i.e. Ursini & Akagi 2013a, b, c).

Before we conclude, we wish to stress that both relations seem to be necessary to account for the semantic relations that hold between SPs. The overlap relation correctly models the relation between pairs of locative SPs (*in* and *on*, *above* and *over*). Works on the production of directional SPs also support, rather indirectly, the possibility that the overlap relation can model relations between these SPs (*from* and *out of*; Papafragou 2010). Thus, its role within a semantic theory of SPs is clear, and perhaps our findings make even clearer its crucial role within a semantic theory of SPs. Hence, we think that our evidence complements the experimental evidence that covers locative SPs in an elegant way.

3. Conclusions

In this paper we presented a study on whether speakers access the entailment or overlap relation as holding between directional and locative SPs, a topic still poorly understood. We chose to test the pairs of directional and locative *to* and *at*, *from* and *at*, as they provided two protoypical pairs of directional and locative SPs. We then employed a variant of the Truth Value Judgment Task to test this experimental hypothesis. This variant involved the narration of complex stories, in which each "sub-story" had the goal of testing each of the SPs under discussion. Given the narrative and temporal connection between the sub-stories, this variant allowed us to test which lexical semantic relation

among SPs the speakers would accept: the overlap or the entailment relation.

Our findings were that speakers accessed the entailment relation, rather than the overlap relation, as holding between these two pairs of directional and locative SPs. The overlap relation, on the other hand, is accessed when speakers interpret sentences involving SPs belonging to the same type, as amply documented in previous research. Hence, both relations contribute to form part of speakers' lexical knowledge of the semantics of SPs. We think that these findings are a welcome result from a theoretical and experimental perspective. We conclude by discussing some topics that we leave aside, hopefully for future research.

This paper does not exhaust the space of empirical investigations on SPs. Two questions can be identified that seem to warrant further investigation, which were mentioned but not discussed in any detail.

First, our paper leaves open the question of whether speakers can access both the entailment and overlap relations over directional SPs. Very indirect evidence that this could be the case comes from the production studies that were discussed in section 1.3. (Stringer 2005; Papafragou 2010). Since speakers may opt for different but semantically related SPs to describe the same scenario (*from* and *out of*), a possibility is that this choice is based on their overlap in meaning.

Second, our paper also leaves open the possibility of an entailment relation defined over directional SPs. Again, a very indirect form of evidence exists in the studies about SPs' production as we discussed. One may argue that differences in production between the more "specific" *into* and the more "general" *to* may support the existence of an entailment relation defined over directional SPs.

These questions are only some of those which our findings seem to invite. Other questions can be formulated as well, as one would expect from such a complex topic. However, we were not able to address the preceding and other questions about the semantics of SPs in this paper, but instead leave them for future research.

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