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The Acquisition of English Spatial Prepositions: The Case of Logical Relations

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This paper offers experimental evidence concerning children’s abilities to access two types of logical/lexical relations that hold among spatial prepositions. One is the sub-set relation that holds between the spatial prepositions “in” and “at”, the other is the relation of entailment that holds between “at” and “to”. The findings presented in the paper suggest that two hypotheses about the semantics of these prepositions hold. First, children appear to access and consolidate these interpretations in a step-wise fashion. Second, the logical/lexical relations between these prepositions may be accessible to children only after the interpretations of the involved prepositions are also accessible, but not before. These findings suggest that children may acquire logical relations among lexical items by interpreting these relations as “emergent” properties of lexical items. These findings are also discussed with respect to two competing theories of language acquisition, the Continuity and the Construction hypotheses. It is shown that the findings are consistent with the Continuity hypothesis, while they offer evidence that challenges some of the core assumptions of the Construction hypothesis.

1. Introduction

The acquisition of English Spatial Prepositions (e.g. in front of, behind and on top of; henceforth: SPs,) has been the topic of much experimental investigation (Brown 2004; Slobin 2004; Stringer 2005; among others). However, the acquisition of the semantic relations that hold between these prepositions is still a poorly understood phenomenon. Two key semantic relations among SPs, the relations of sub-set and entailment, are shown in examples (1a)-(1b) (Parsons 1990:76-82; Nam 1995; Feist 2006):

(1a) Mario was in the park⊆Mario was at the park
(1b) Mario will go to the park→Mario will be at the park

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1 We would like to thank our two children and their mothers for participating in the study; Crain, Rosalind Thornton, Drew Khlentzos and Aijun Huang, Esther Su, Peng Zhou, and two anonymous reviewers for the very useful and constructive feedback. The usual disclaimer applies.
Consider (1a), first. It is generally acknowledged that *at* denotes a region encompassing a landmark object and its "surrounding" regions (Nam 1995; Levinson & Meira 2003; Feist 2006). Therefore, if Mario is in the "internal" region of the park (i.e. “in” the park), then he will also be in the broader region that includes this specific location, or "at" the park. Therefore, the meaning of the first sentence stands in the *sub-set relation*, represented as “⊆”, with the meaning of the second sentence. Since the two SPs *at* and *in* form the minimal pair that distinguishes these two sentences, this relation can be ascribed to the two SPs. Therefore, the sub-set relation can be conceived as a *lexical relation* among these two SPs, and modelled as a logical relation (Murphy 2010: ch.1-2).

Consider now (1b). Intuitively, if the boy will be at the park, it is because he will have reached the park after a certain event of motion. While *to* in the first sentence captures this notion of directed, goal-based motion, *at* in the second sentence denotes the goal region that Mario will reach, after moving. As in the example (1a), since the two sentences form minimal pairs with respect to the SPs they include, the relevant semantic relation is defined over these SPs. This relation is *entailment relation* between *to* and *at*, since the truth of the first sentence entails the truth of the second sentence (Murphy 2010: ch.1-2). Both (1a) and (1b) show specific relations that can be generalised to other SPs as well (e.g. *on* and *at*, *into* and *in*, respectively).

The semantic relations of entailment and sub-set seem to accurately account for speakers' intuitions about the meanings of spatial SPs, and the semantic/lexical relations that hold among these meanings. However, it is an empirical question on whether children can access these relations and, if they can, whether these relations guide their emergent semantic understanding of SPs. We do not know, *yet*, *how* and *when* children can access these relations among SPs, and *what* the role of these relations in their acquisition of SPs is, as distinct lexical items. In pursuing these empirical questions, we also pursue a broader empirical question on which hypothesis of language acquisition may be better suited to account for and predict our findings. In this paper we discuss two hypotheses, presented below.

The first hypothesis is known as the *Continuity hypothesis*. This hypothesis suggests that children can access lexical relations in an adult-like manner, *after* accessing the semantic representations of the relevant items. In our case, children would first acquire the semantic representations underlying the SPs in (1a)-(1b). Then, they would access the relations that hold among SPs, as a logical consequence of accessing the meanings of each SP involved in these lexical relations. Examples of frameworks that take this approach to the emergence and
acquisition of logical relations tend to fall within the generative strand of linguistics (Pinker 1984; Crain 1991; Crain & Thornton 1999: ch.1).

The second hypothesis is known as the Construction Hypothesis. Distinct frameworks within the broad field of Construction Grammar share this hypothesis, although they diverge on other matters (Tomasello 2003; Goldberg 2006). According to this hypothesis, children can access lexical relations as defined over complex constructions, including sentences, without necessarily being able to access the meanings of the constituent words of these constructions. The use in context of these sentences can determine that the sentences stand in a certain semantic relation. So, this hypothesis would predict that children can access the lexical relations in (1a)-(1b) before they could access the meaning of the SPs in, to, at. Insofar as children can understand in which contexts both sentences are appropriate, they may not know the actual meaning of each SP. Hence, this hypothesis makes a different set of predictions than the Continuity hypothesis.

The goal of this paper is to offer empirical evidence that answers our research question: whether and how children acquire these lexical relations among SPs. In doing so, we also aim to test whether the Continuity or the Construction hypothesis offers a more accurate account of the acquisition of SPs in children. Hence, we aim to uncover which family of approaches offers a more accurate account of the emergence of logical relations in children’s languages, at least with respect to SPs.

This paper is organised as follows: in the rest of the introduction, we introduce some basic theoretical notions (section 1.1.), then we discuss previous experimental findings concerning their acquisition (section 1.2.). In section 2, we present two longitudinal studies that involved a child each, and their acquisition of these logical relations. In section 3, we offer our conclusions.

1.1 Theoretical Background

The goal of this section is to present some basic notions on the semantics of SPs, and make precise the nature and content of their logical relations. We start by focusing on core semantic notions, and leave aside any syntactic considerations. The reader is invited to consult recent literature on the syntax of SPs, for this specific topic (Hale & Keyser 2002; Svenonius 2006, 2010). It is generally acknowledged that SPs denote two “layers” of meaning. A first layer denotes a relation between a located entity and a landmark object, respectively labelled as figure and ground (Talmy 1978; 2000). This first layer captures the concept that the position of the figure is “computed” with the ground, as the centre of a spatial reference system. A second layer restricts this general spatial
relation to one that involves a certain “sub-set” of possible positions that the figure may occupy, with respect to the ground. For instance, both in and at denote a spatial relation between figure and ground, but differ on the specific locations involved. In denotes a set of positions in which the figure is in an internal “part” of the ground (Jackendoff 1983, 1990); while at denotes a “larger” set of positions, both internal and external, and close to the ground (Nam 1995; Vandeloise 2010).

The classic argument for the existence of this second layer is known as the “argument from modification”, found in the “event semantics” literature (Parsons 1990; Zwarts 1997; Zwarts & Winter 2000; Landman 2000). The argument is based on the fact that SPs can combine with modifiers such as measure phrases (e.g. ten meters) and modifiers that denote directions (e.g. right). These modifiers do not denote a property of figure and ground, but of some other “geometrical” referent that SPs seem to implicitly denote. Measure phrases and other modifiers, instead, can explicitly denote this referent. Consider (1c)-(1d):

(1c) The boy sits ten meters right in front of the table
(1d) The boy walks ten meters right towards the table

As it has been argued in the literature, this implicit reference should actually be conceived as a set of referents, of which these modifiers select a certain sub-set. Hence, ten meters selects a sub-set of positions that are located at a certain distance from the ground. Although most frameworks agree upon these basic notions, the exact nature of these implicit referents is a matter of intense debate. Traditional Event/Situation Semantics approaches suggest that these referents are eventualities or situations (Parsons 1990; Fong 1997, 2001; Kratzer 2003, 2007; Rothstein 2004; Ursini & Akagi 2013, c, d). Other approaches suggest that more specific or distinct “geometric” entities such as regions, vectors or paths are called for, to capture these data (Jackendoff 1983, 1990; Kracht 2002; Zwarts 1997). Approaches that combine both proposals to some degree also exist (Link 1998; Krifka 1998; Kamp, van Genabith & Reyle 2005; Ramchand 2008). A definite consensus on this matter, however, is still outstanding.

However, regardless of the different ontological commitments, it is generally assumed that the differences in lexical meanings among SPs can be based on the specific sets of implicit referents they individuate. Therefore, it is also assumed that any lexical relations that can be defined over SPs stem from their ability to denote distinct, but related sets of positions. The case of in and at, as we discussed, is one prime example. Assume that in denotes a set of positions in which the figure is “internal” to the ground, and that at denotes a set of positions that includes this position. If this is the case, then a logical conclusion is that the
set of positions denoted by *in* will be part of the set of positions denoted by *at*. In other words, the lexical relation that holds between *in* and *at* emerges as a consequence of their basic lexical semantics. The semi-formal use of the sub-set relation in (1a) aims precisely to represent this fact.

The entailment relation that holds between SPs such as *to* and *at* and displayed in (1b), instead, involves a subtler aspect of the logical relations that hold among SPs. A standard assumption is as follows. SPs denoting directed motion or “directional” SPs, such as *to, through* and others denote different semantic structures than their “locative” counterparts (e.g. *in, at*) (Cresswell 1978; Jackendoff 1983; Zwarts & Winter 2000). Directional SPs denote positions that are ordered along a certain “direction”, for instance the one between moving figure and ground, taken as the end-point or “goal” of this direction. Since we are reasoning with ordered sets (or sequences) of positions, it is more opportune to talk about goals or end-points, seen as the set of positions that a figure can reach. These sets of ordered positions, or sequences, make up the denotation of *to*. The set of positions in the denotation of *at*, then, is a sub-set of positions which are at the “end” of the sequences of positions that *to* denotes.

So, the entailment relation in (1b) denotes a logical relation between *to* and *at*, as a relation between two relatively complex sets. This is also a relatively standard assumption in the literature (Fong 1997; Kracht 2002; Zwarts 2005, 2008). For our purposes, this entailment relation can be reduced as a relation between two sets. One is the set of ordered positions that are in the denotation of *to*, and the other is set of positions that can be individuated as the denotation of *at*. The entailment relation in (1b), then, represents another logical/lexical relation that is a logical consequence of the semantic properties of SPs and, in this case, of the lexical semantics of *to* and *at*. One working assumption that emerges from these facts, then, is that at least the lexical relations of sub-set and entailment, as defined over *in* and *at, to* and *at*, form part of the lexical knowledge of speakers. We discuss whether this is indeed the case in the next section.

1.2 Experimental Background

The goal of this section is to discuss previous relevant findings on the acquisition of SPs, from a purely semantic perspective. If one looks at the vast literature on SPs, it is seems uncontroversial that children acquire the semantic representations for these lexical items by following a “scale” of increasing lexical complexity. Children seem to first acquire “basic” SPs, and then SPs of increasing semantic complexity. For instance, early studies on production (Clark 1973) reported the early emergence of the preposition *in*, in children young as 1;3
years, who overproduced *in* as a sort of “general” preposition. Several other works found that children would acquire other locative SPs such as *on, at* at later stages (e.g. 3;5 years for *at*: Miller & Johnson-Laird 1976: 506-562, Durkin 1981). In doing so, they often overgeneralise the meaning of these SPs, only to get a more accurate interpretation at a later time.

This is consistent with more recent cross-linguistic findings that suggest that children may access the meaning of *in* and its use in context. They may do so, even before they will be able to produce this SP (Rohlfing 2001, 2005; Choi & Rohlfing, 2010). Overall, these findings suggest children first acquire the meanings of single SPs, often accepting these meaning as covering those of other SPs. When children acquire the ability to access more meanings and relate their semantic range, then children seem to assign a more accurate interpretation to these SPs. This occurs, though, after children can access the meanings of each SP.

Other works that investigate the acquisition of “projective” locative SPs, such as *in front of, behind* and others suggest a similar picture. Children acquire basic projective SPs such as *top* and *bottom* before semantically richer ones, such as *above* or below (Johnston & Slobin 1979; Clark 1980; Johnston 1985, 1988; Clark & Carpenter 1989). Recent findings seem to further support this view, as they look at the relation between *in front of* and *behind*, but also *in* and *inside* (Torseng 1997; Sinha, Thorseng, Hayashi & Punkett 1999; Richards, Coventry & Clibbens 2004; Richards & Coventry, 2005; Coventry & Guijarro-Fuentes 2008). Furthermore, cross-linguistic works suggest that this is a general pattern. Examples include Korean (Choi 1997, 2006; Bowerman & Choi 2001, 2003, 2007) Dutch, German (Bowerman 2007) Tzeltal (Brown 2004), French (Vandeloise 1994, 2005); British Sign Language (Clibbens & Coventry 1996). Overall, children seem to acquire locative SPs according to the SPs’ increase in semantic complexity. In doing so, they also acquire the subtle lexical relations that hold among SPs.

A general pattern that further supports this view pertains to the acquisition of directional SPs. Recent works offer similar evidence for the production of directional SPs (Stringer 2005, 2006a, 2006b). These studies found that children may produce directional SPs as early as 3;0 years of age (e.g. *across, along, through*). In doing so, children seem to follow a general pattern by which directional SPs tend to emerge at a later stage than most, if not all locative SPs. Nevertheless, these findings also suggest that the lexical relations that hold among SPs may also guide these processes. For instance, children may produce the coordinated SPs *in and out of* as being true in the same context of *through*, or even produce this coordinated SP before *through*, in a “traversal” context.
Findings that support the view that lexical relations emerge in a child’s language from the acquisition of the lexical semantics of SPs are reported in the research by Dan Slobin and associates. These works use an elicitation task known as the “frog task”\(^2\). In this task of semi-naturalistic style, experimenters use an illustrated, text-less book which depicts the adventures of a wandering frog. These pictures attempt to elicit descriptions of spatial configurations by children, who are asked to describe the pictures in the stories (the frog going under a tree trunk). Several works document English-based findings (Slobin 1996, 1997, 2000, 2003, 2004, 2005). Other works, instead, offer equivalent cross-linguistic evidence (Slobin, 2003, 2005; Slobin & Bocaz 1988; Berman & Slobin 1994; Ragnarsdóttir & Strömqvist 1997; Naigles and Terrazas 1998; Brown 2004). A general pattern in these works is that children produce SPs starting from the semantically simple locative ones (e.g. *in*), and slowly move to more complex SPs, as they grow in age and linguistic skill. In doing so, children also seem to acquire lexical relations as a consequence of their new-found ability to assess the adult-like interpretation of each SP.

A similar wealth of evidence exists for speakers’ production and comprehension of SPs and their logical relations. Several recent works have investigated how adults can access the spatial interpretation of *in* (and *on*). These works support the view that *in* mostly denotes an inclusion relation between figure and ground (Coventry 1998, 1999; Feist 2000, 2002, 2004, 2006, 2008, 2009, 2010; Feist & Gentner 2002, 2003; Breaux & Feist 2010). Other works support the hypothesis that adult speakers of English interpret *at* as denoting a more general spatial relation (Feist 2006, Ursini & Akagi 2013a, 2013b). Works on *to* have found that speakers interpret this SP as denoting a relation in which the figure moves in direction of the ground, and reaches it (Papafragou, Massey & Gleitman 2002; Regier & Zheng 2003, 2007; Lakusta & Landau 2005, 2012; Papafragou 2010). Furthermore, some of these works also found in what contexts speakers can accept the entailments in (1a)-(1b). Their findings support the hypothesis that, at least for adults, the sub-set relation between *in* and *at* holds (Feist 2006, Ursini & Akagi 2013a), and so does the entailment relation between *to* and *at* (Stringer 2005a; Papafragou 2010). Therefore, adults seem to interpret the three SPs *in*, *at* and *to*, and their sub-set and entailment relations, as per theoretical hypotheses.

Overall, the experimental literature on SPs strongly supports the idea that children acquire SPs by following certain incremental, logical principles. Such principles, in turn, seem to reflect the shared semantic properties of SPs as a

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\(^2\) The “frog, where are you?” stories originate from an old children’s book from the 60s (i.e. *Meyer 1969*).
syntactic and semantic category, properties that adults can access as per theoretical hypotheses. However, a still lingering empirical question is whether and how children can explicitly access the two logical relations under discussion, since no previous study has investigated this possibility. In other words, we still do not know whether and how children can access the sub-set relation between *in* and *at,* and the entailment relation between *to* and *at.* We address this question in the next section.

2. The Experiment

In this section we present two distinct experiments on the acquisition of SPs. The first experiment focused on their acquisition by one child, age range 3;1-3;11 years. The second experiment focused on a younger child, age range 2;3-2;11 years. We introduce the task used in the experiments in the rest of this introduction, and the variants we used in each experiment in each sub-section.

In each experiment we used a simplified variant of the *Truth Value Judgement Task* (henceforth: TVJ task) (Crain & Thornton, 1999). We will briefly motivate this choice and summarise how the standard format of the task works, referring the reader to Crain & Thornton (1999) for a more thorough introduction. We chose this task, as other tasks (e.g. the “frog task”) focus on *production,* hence they do not allow the testing of children’s *comprehension* of SPs, hence for their semantic relations. One variant of a TVJ task works as follows. One experimenter presents a scenario to a child in which certain events unfold. The experimenter also controls a puppet, who narrates these events. The second experimenter records the sessions. At the end of the story, the puppet offers a question to the child about the events, which tests the child’s comprehension of a target string. For instance, a story can involve five horses that race to a lake, but only four of them actually reach the lake. One horse falls and never reaches the lake, although he explicitly stated his wish to do so. At the end of this story, the puppet asks this question:

(1e) Has every horse gone to the lake?

If a child answers “no”, then this child can access the meaning of the underlying declarative sentence, as the sentence is false, against this scenario. Conversely, if the child answers “yes”, then this child cannot access the predicted interpretation of this sentence. After the answer, the experimenter asks a follow-up question to the child, asking the child to motivate the answer given. If the child defends the answer given by pointing out that one horse failed the task, then one can infer that the child can access the intended meaning of the sentence.
One important factor is that in this and similar scenarios, both a “yes” and “no” answer are plausible answers, as describing possible outcomes of the story. This is the Condition of Plausible Dissent (henceforth: CPD). Although this condition is far from controversial (see Meroni, Gualmini & Crain 2006 for a review), it grants that one can test “positive” scenarios as well. In a scenario in which one horse struggles to reach the lake but can complete the task, a child can answer a question such as (1e) with a “yes”. This answer would be perfectly acceptable, provided that in the follow-up answer the child points out that one horse only completed the task at a later time. Some more specific aspects of the task are explained below.

2.1 Experiment N.1: Terence P.

This experiment aimed to test how the different prepositions and their interpretations became accessible over developmental time.

2.1.1 Participants

The child involved in this experiment was Terence P. Terence P. attended 17 fortnight-based interviews while in the age range 3;1-3;11 years.

2.1.2 Materials

Each session was recorded via the use of a video-camera. In all the sessions, the child’s mother was present, but she was not aware on the nature of the tasks. No mention was made of the experimental hypotheses in any extra-session chat. Each session involved several mini-stories that tested both how the child interpreted to, at and in in isolation, but also how he interpreted the two relations of sub-set and entailment. The main goal was to test whether Terence P. acquired the semantic representations for these SPs before or after he acquired their lexical relations, as per experimental hypotheses. To avoid the possibility that the child memorised answer patterns, a wide choice of different “tank engines” and locations was used, for a total of 41 different engines and 18 different locations. Each task usually involved a different motion verb (e.g. going, jumping, running, etc.) and location verbs (e.g. sitting, sleeping, eating, etc.). So, each test sentence was tested against a different implicit context. Typical test sentences followed the general schemas displayed in (1f)-(1h):

(1f) Have all the Xs gone to the Y?
(1g) Are all the Xs Z-ing at the Y?

3 The pseudonym is an obvious homage to Terence Parsons, as the child's true name is here omitted as part of normal privacy procedures.
(1h) *Are all the Xs Z-ing in the Y?*

The $X$, $Y$ variables stand for noun Phrases, the $Z$ variable for verbs. For instance, a question involving *in was are all the engines sleeping in the station*, while a sentence involving *to was have all the engines gone to the shop?*. Other questions varied in the specific content under discussion, but not in their underlying syntactic and logical structure. Each sentence included the universal quantifier *all* in the subject noun phrase, as this quantifier forces a distributive interpretation (Brisson 1998, 2003). So, the underlying declarative sentences would be true in context if each of the referents of a noun phrase would be in a certain spatial relation with a ground (e.g. all the engines in a context). For each sentence employed in the experiments, we had a group of native speakers ($N=3$) to verify their grammaticality. The puppet involved in the stories was a Godzilla prop, which narrated all the unfolding events to the child, and then made all the test questions based on these events. After each session, the experimenters transcribed and analysed the data as per the hypotheses. In certain cases, it was not possible to transcribe some words because of intervening factors, so this “noise” was reported as “[xxxx]”.

2.1.3 Procedure

In each session, the first and final two or three minutes involved unstructured play time, so the child could get acquainted with the environment. For each hypothesis, the puppet Godzilla narrated a scenario unfolding in front of the child, and involving different characters. At the end of each story, Godzilla asked one of the question-types in (1f)-(1h), which were contextually appropriate questions for the story narrated so far. The standard explanation offered to the child was that since Godzilla had a poor memory, he could not properly recall what events occurred during the stories. So, the child had to help Godzilla by answering his questions. After each answer, Godzilla answered a follow-up question (e.g. “what happened?”). Given the Condition of Plausible Dissent, each answer was considered valid when the child defended his choice as being consistent with the context.

When the single *to, at, in* hypotheses were tested, the target question was followed by a fill-in series of events, in which no relevant target SPs were tested. When the entailment and sub-set hypotheses were tested, two questions in a row were presented. For instance, in one story five tank engines decided to have lunch at a restaurant, and went to this location for this purpose. One engine got lost while travelling to the restaurant, and was able to reach its goal only after a
detour. After narrating these events, Godzilla asked to the child the question in (1i):

(1i)  Have all the tank engines gone to the restaurant?

Godzilla then asked a follow-up question that either invited the child to elaborate his answer (“what happened?”) or asked about the almost-missing engine (“What about Duncan? Did he arrive, too?”). In stories that aimed to test the to→at entailment, instead, the story continued and described the engines performing some consequent action: in this case, eating lunch. Again, one character struggled to complete the action, unlike the other characters, but ultimately managed to catch up with the other characters. The type of question offered in (1i) was immediately followed by (1k):

(1j)  Are all the tank engines eating lunch at the restaurant?

When two questions were offered in a sequence, two follow-up questions were also offered to the child. For instance, if a sentence such as (1f) was asked, followed by a sentence such as (1g), the child was motivated to answer each of his two answers, to the best of his skills. Each session, once completed, was transcribed and marked for scoring. When it was tested whether children interpreted to and at as per standard analysis, each single case was scored as “correct” when the child interpreted these SPs as per assumptions. When a child did not do so, then each answer was scored as “wrong”. As in few cases the child did not offer any answer, either by falling silent or answering something else, the third value “not sure” was added. Before we offer the results, we briefly rehearse the predictions for both the Continuity and the Construction hypothesis. The Continuity hypothesis predicts that Terence P. first acquired to, at and in and then their lexical relations. Instead, the Construction hypothesis predicts that the lexical relations could have emerged beforehand.

2.1.4 Results and Discussion

The results for the interpretations of SPs were as follows. Terence P. could correctly answer questions including to and in by age 3;1 years, and sentences including at by age 3;5 years. Terence P. could not correctly answer questions related to entailment (i.e. those involving to and at) and sub-set relations (i.e. those involving in and at) before age 3;6 years. During the testing period, these answers converged to an adult-like interpretation, as Terence P. could answer correctly most of the time. The results for the SPs in isolation are in (1k), those for the lexical relations in (1l) (answers are listed as “yes/no/not sure”):
If we assume that both “no” and “not sure” answers were at chance (i.e. 5% rate), then the percentage of undefined answers was not statistically significant\(^4\). Furthermore, the first errors appeared at a later time, respectively at the 10\(^{th}\) (for to), 10\(^{th}\) (for at) and 8\(^{th}\) (for in) session. One crucial aspect regards the at-type. For the first five sessions, Terence P. either did not answer or answered at-type sentences erroneously. However, by the sixth session errors became rarer, so they could be attributed to performance factors. This suggests that at became part of his grammar after 3;3 years of age, while the other prepositions already emerged beforehand. The typical entailment stories also can be useful to illustrate the specific type of task and Terence P.'s answers. An example is the following mini-dialogue:

(1m) Exp.: “Oh guys, have all the tank engines gone to the farm T.P.?”
   T.P.: yes [true]
   Exp.: “but are all the tank engines at the farm now?”
   T.P.: yes [Freddie is out, others in]

In this case, taken from Terence P.'s 14\(^{th}\) session, Godzilla (the experimenter acting as the puppet) asked an at-question right after the child answered a to-question. The child accepted a case in which one tank engine was outside, and all tank engines were in the shed. The entailment relation between at and in is also tested via these sentences:

(1n) Exp.: “are all the tank engines at the farm now?”
   T.P.: yes they are, look [waits a second before answering, “in” is true too]
   Exp.: “Oh wait let me be sure, now all the tank engines are in the farm, is that right, let me count”
   T.P.: yes, they are

In (1n) the tank engines were lying inside a toy farm with surrounding fences, as a result of a prior event of motion, and Terence P. accepted both at and in sentences as being appropriate descriptions (true) of the facts. While in is in a sense more appropriate, in this context, the child also accepted at, as per

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\(^4\) For instance, in the case of the sub-set relation, a \(\chi^2\) test on the “not sure” answer yields the results \(\chi^2=2.4, p^*<.30\), thus confirming that the data are within the experimental hypotheses.
predictions. As the results stand, they strongly suggest that Terence P. first accessed the interpretation of the SPs in, at and to, in an adult-like fashion. Once he was able to do so, he was able to access the lexical relations that these SPs share. In other words, these results invite the conclusion that the Continuity hypothesis seems better suited to account for the emergence of lexical relations than the Construction hypothesis, in Terence P.’s grammar.

2.2 Experiment N.2: Fred L.

This Experiment aimed to test the interpretation of experimental hypotheses in a younger child, nicknamed “Fred L.”

2.2.1 Participants

Fred L. is the second of the two children who participated in the study, at age range 2;2-3;0 years. Fred L. was interviewed in 18 fortnight sessions.

2.2.2 Materials

Each session was recorded according to the procedure described in the previous section. The tasks and questions were identical with the ones used in the first experiment. A special mention concerns the use of puppets. Fred L. often showed a strong “intolerance” of the presence of any marionettes on display. He often got distracted, or tried to take the experimenter’s role in using the puppet. For this reason, one experimenter narrated the stories and directly offered the questions to the child, including the follow-up ones. This decision solved Fred’s attention problem, as the child was able easily to focus when no puppets were employed. In this case, answers only met the CPD condition, but not the “experimenter’s positive bias” condition. However, previous research on children in this age range suggests that positive biases towards adult experimenters are quite limited, if not absent. A consistent pattern in children age 2;0-3;0 years is that they can offer (adult-like) answers, even if the experimenter asks the questions (e.g. Unsworth, 2005; Notley, Jensen & Ursini 2008). Hence, the data based on this type of answer can be also seen as evidence of Fred L’s interpretation of the target prepositions, although of a fairly less direct type. This aspect will be discussed in the results section, when relevant.

2.3.3 Procedure

Each session followed the procedure discussed in the previous section, modulo the lack of Godzilla as an experimental prop.
2.3.4 Results and Discussion

The main findings of this experiment were that Fred L. could access the predicted interpretation of to and in by the age 2;4 and 2;3 years, respectively. The child could then maintain an adult-like interpretation of these SPs for the remainder of the study. However, Fred L. did not display an adult-like comprehension of at during the study, as he was able to answer according to our predictions only during later sessions of the study. The percentages of answers are as follows:

(1m) TO=82.7/3.4/13.9(N=29);
    AT=30.7/7.6/61.7(N=13);
    IN=81.8/4.5/13.7(N=22);

These data suggest that Fred L.’s interpretation of the target prepositions was overall at an earlier stage than the one observed in Terence P. The data on positive answers require some careful consideration. A general pattern was that Fred L. became easily distracted when he was invited to observe at-type stories, hence he made the testing of our lexical relations logistically hard. All our attempts to test this SP can therefore be considered as falling in the “not sure” category. The statistically significant “undefined” answers for at also suggest the child was still not able to access the interpretation of this SP, at least not during the period of the study. This finding is consistent with the findings in the first experiment. If Terence P. had problems in accessing at before 3;3 years of age, then Fred L. should have also been unable to access this SP given his younger age. An important fact was that, as in Terence P.’s case, Fred L. was able to defend his answers when asked. He did so by e.g. pointing out that one ball was “not yet” in the bin, or (forcefully) claiming that all tank engines went to the station. Overall, Fred’s data allow us only to shed light on how children can access some of the basic building blocks of the lexical relations under discussion. Fred L. could interpret to and in according to predictions. However, the unstable interpretation of at suggests that the two logical relations still had to emerge.

2.4 General Discussion

We begin our general discussion from Terence P.’s experiment. The first experiment offered evidence of whether Terence P. could access the lexical relations between the SPs in and at, and to and at. It also offered evidence of whether he could do so, before or after the acquisition of the single SPs’ meanings. Terence P. accessed the entailment and sub-set relations at later phases of the experiment, with these relations “guiding” the acquisition process.
As per predictions of the Continuity hypothesis, Terence P. could accept the sub-set and entailment relations once he could access the building semantic blocks of these relations, the meanings of in, to and at. These findings also suggest that the Construction hypothesis may require some revisions, to account for these data.

The second experiment offered evidence of whether Fred L. Since the data were collected during Fred's third year (age range 2;2-3;0 years), they offered more preliminary evidence than the one found in Terence P.'s study. Nevertheless, this evidence suggests that the acquisition of the single SP at acts as a preliminary step to the acquisition of the sub-set and entailment relations in which this SP is involved. Fred did not answer to any questions involving at and its logical relations, hence displaying the same developmental pattern of Terence P., but at an earlier phase. A possible interpretation is that Fred's data support a more neutral, but nevertheless logical approach of children's acquisition of lexical relations. Since Fred was not able to access the interpretation of one of the logically-connected SPs, he could also not access the relations themselves. This can be seen as consistent with both the Construction and Continuity hypothesis, although the Continuity hypothesis would expect this result, albeit in a very indirect way."

3. Conclusions

In this paper we presented a study on the acquisition of the sub-set and entailment relations among SPs, focusing on respectively the relation between in and at, and to and at. Our more specific goal was to shed light on these poorly understood aspects of language acquisition, as well as investigate how children would interpret these SPs. Our broader goal, instead, was to investigate whether the Continuity or the Construction hypothesis could offer an accurate account of our findings. The Continuity hypothesis would predict, for our scenario, that the two children we tested would have acquired the meanings of these SPs at a first time. Afterwards, building upon this new-found lexical knowledge, the children would have acquired the sub-set and entailment relations among these SPs. The Construction hypothesis, instead, would predict that the two children could have acquired the lexical relations before acquiring the meanings of each SP. As the results show, the Continuity hypothesis offers more accurate predictions of how these relations emerge in at least our older child, and seems to be consistent with the findings of the younger child. The Construction hypothesis, instead, may be consistent with the younger child’s findings, but not with the older child’s.

These findings leave open several empirical questions, of which we only list one, for reasons of space. The findings leave open the question on how children
may generalise these relations to other SPs. We focused on the sub-set relation as it is defined between *in* and *at*. However, it is generally acknowledged that this relation may be defined over other SPs as well (e.g. in front of and at: Nam 1995, Levinson & Meira 2003). Therefore, an empirical question is whether children can acquire these relations and, in doing so, they follow the pattern displayed at least by Terence P. for *in* and *at*. A similar case can be made for the entailment relations that hold between *into* and *in*, or similar other pairs (Parsons 1990; Fong 1997). We leave these questions, however, for future research.

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