Acquisition of Resultative Constructions in English- and Mandarin-Learning Children: 
A Test Case for Participant-Argument Matching

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I. Introduction

Verbs pick out events. For example, the verb ‘cut’ picks out a CUTTING event. Verbs also occur in certain syntactic environments. For example, the verb ‘cut’ occurs in transitive clauses with two noun phrases, one denoting the agent of the CUTTING event, and the other the patient. What is the relation between the event denoted and the syntactic environment of the verb? A relatively standard view holds that the syntactic arguments of the verb reflect all and only the entailed participants in the event; in other words, every time the verb occurs, it occurs in company with overt arguments corresponding to all of the participants in the event it denotes. And in the literature on acquisition, many researchers have reported that child learners seem to adhere to this standard generalization. That is, children seem to exhibit an early bias to interpret a clause with N argument noun phrases as describing an event with N participants. Let’s refer to the hypothesis that children are biased to match noun phrase arguments to participants one-to-one as the Participant-Argument-Matching Hypothesis, or PAM for short.

There is important initial evidence in favor of PAM (Fisher, 1996; Fisher et al., 1994; Gleitman, 1990; Landau & Gleitman, 1985; Lidz, Gleitman & Gleitman, 2003; Naigles, 1990; Naigles & Kako, 1993; Yuan & Fisher, 2009; Lee & Naigles, 2008; inter alia). But many avenues for testing this hypothesis have not yet been explored, among which we are particularly interested in PAM in the context of a complex clause with a complex predicate. Complex structures beyond simple transitive and intransitive clauses have seldom been investigated, leaving open the
question how generalizable across structures PAM is. Importantly, in the context of a complex clause with complex predicate - one comprising two or more predicate words - a distinction between two possible versions of PAM that cannot be seen in simple clauses emerges. One we call the Word-Based PAM, or W-PAM for short, and we believe this is the version most people have in mind when testing it with simple transitive or intransitive clauses. We call the other version the Sentence-based PAM, or S-PAM. The crucial distinction between these two versions lies in what events are being referred to: the former talks about the sub-events denoted by each predicate in the sentence, whereas the latter talks about the event denoted by the whole clause. The difference cannot be seen in simple one-predicate clauses, because the event picked out by the verb is identical to the event picked out by the clause. Therefore, extending the study on PAM to more complex structures carries theoretical significance.

We use the Resultative Construction (henceforth RC) as the test case. This construction, with a complex predicate structure, calls PAM into question because of a difference between English and Mandarin Chinese: while in English RCs, the same participant-to-argument mapping in simple clauses applies (i.e. agent of the verb mapped to subject NP, patient of the verb mapped to object NP), Mandarin RCs demonstrate a different mapping requirement than Mandarin simple clauses - Mandarin RCs allow the patient of the main verb to be unexpressed while Mandarin simple clauses require it to be expressed. This variation renders the simple formulation (i.e. W-PAM) of the PAM hypothesis questionable, because not every participant of the event denoted by the main predicate is syntactically realized.

We will also discuss two secondary issues in this paper. First, we will discuss how the fact Mandarin has object pro-drop (also known as zero anaphora or null object pronoun) might influence children’s interpretation of sentences with an NP argument denoted by a novel noun. Previous works have shown the pro-drop / non pro-drop status of the input language does not affect children using PAM as a learning bias, but we will show that its impact may emerge in the context of more complex event structures. Second, because vocabulary development is
shown a better predictor than age of the growth of syntactic knowledge, this paper also discusses how vocabulary knowledge affects child learners’ encoding of a complex sentence, and how this effect interacts with some language-specific properties, for example, pro-drop in Mandarin but not in English, and different word orders of RCs in Mandarin and English.

The paper is organized in the following way: Section II will review the standard view on the participant-argument relation and the PAM hypothesis as a learning bias that guides child learners’ verb learning, and also, will put on the table an important distinction between two versions of PAM that can only be seen in complex clauses; Section III will give a review of the Resultative Construction in English and Mandarin and discuss why it serves as a good test case to the research question concerning children's acquisition of verbs; Section IV will delineate the way this study probes into these questions and discuss current results; and Section V will conclude the paper with some general discussion.

II. Some Background on PAM

1. Event participants and syntactic arguments – a standard view:

At its core, a bare verb labels categories of events (or states). In addition, verbs have a syntactic subcategory, in virtue of which it occurs in some syntactic context and not others. Verbs of one subcategory occur with a direct object, for example, while verbs of another subcategory do not. What is the relation between the event denoted and the syntactic environment of the verb? How do young learners represent this relation – do they think arguments are properties of clauses or of verbs; and how do they use it over the course of language development?

A relatively standard view is that the event denoted by the verb and its syntactic environment is connected via a principled mapping between the syntactic arguments of the verb and the entailed participants in the event; specifically: the syntactic arguments of the verb reflect all and only the entailed participants in the
event as it is mentally represented. As for young learners’ hypothesis, the standard view holds that children have this mapping principle as an unlearned and universal bias, which aids them in recognizing novel verb meanings. In what follows, I will review this standard view in acquisition and its supporting evidence in more detail.

2. Children’s learning bias - the Participant-Argument Match hypothesis:

As is now well recognized, lexical acquisition cannot be built on pure observations of the word-to-world mapping (Landau & Gleitman, 1985), because the extra-linguistic world does not present itself as observable pieces that are readily mapped onto linguistic units. In addition to observational apparatus, therefore, learners must also come into the world prepared with some kind of ‘mental zoom lens’ that will aid them in slicing the world up and picking out relevant information for further processing (Landau & Gleitman, 1985). One such ‘zoom lens’, proposed by Landau & Gleitman (1985) in the widely known Syntactic Bootstrapping Theory (SBT), targeting verb learning in particular, is the syntactic environment of the verb. The fundamental idea of SBT is: there are certain principled relation between verb meaning and verb syntax, which is known to children, and thus children can use this knowledge to infer verb meaning from verb syntax.

‘Children’s sophisticated perceptual and conceptual capacities yield a good many possibilities for interpreting any scene, but the syntax acts as a kind of mental zoom lens for fixing on just the interpretation, among these possible ones, that the speaker is expressing. To make use of this information source in acquiring the verb vocabulary, the learner must perform a sentence-to-world mapping rather than a word-to-world mapping.’

--- Gleitman (1990), page 23

This principled mapping between verb meaning and verb syntax, in its strongest version, states that the semantic space of verb meanings is partitioned based on the range of subcategorization frames (Gleitman, 1990). One important aspect of this theory, as fleshed out in Lidz, Gleitman & Gleitman (2003), captures the relation between participants and arguments: ‘Every participant in an event as it is mentally represented shows up as a syntactic phrase in a sentence describing that event’. In other words, learners could use the number of phrasal arguments in
the sentence to infer the number of participants in the event denoted as it is mentally represented, so as to narrow down their hypothesis about the meaning of the verb, i.e. what type of event the verb picks out. For our purpose, we refer to this aspect of SBT as the Participant-Argument-Match hypothesis, henceforth, PAM.

There is abundant experimental evidence that is consistent with PAM (Fisher, 1996; Fisher et al., 1994; Gleitman, 1990; Landau & Gleitman, 1985; Lidz, Gleitman & Gleitman, 2003; Naigles, 1990; Naigles & Kako, 1993; Yuan & Fisher, 2009; Lee & Naigles, 2008; inter alia). For example, Naigles (1990) demonstrated that children around 2 years of age could use the number of noun phrases in a sentence as cues to make inferences about the meaning of a novel verb, namely, what type of event the novel verb labels: in a Preferential Looking Paradigm, 25-month-olds were familiarized with a complex event in which a duck was pushing a bunny down while both of them were swinging their arms around; half of the child participants also heard a transitive sentence “the duck is gorping the bunny” concurrently with the event, whereas the other half heard an intransitive sentence “the duck and the bunny are gorping”; later when they were given two sub-events decoupled from the complex one, those who heard the transitive sentence looked longer at the sub-event in which the duck pushed the bunny down than at the sub-event in which the duck and bunny were swinging their arms, while those who heard the intransitive sentence showed the opposite looking preference. Yuan & Fisher (2009) pushed this finding one step further by removing the concurrent scenes from the familiarization, which presumably hinted at the verb's semantic content; and they showed that around the same age (28-months), children could glean some structural information from the sentence alone and later use it to guide their attention to certain candidate event: children were played some brief dialogues containing either the transitive structure “Jane blicked the baby” or the intransitive structure “Jane blicked”, and later were presented two events side-by-side on the screen; when asked to find the blicking event (e.g. “Where’s blicking”), those who heard the transitive sentence looked longer at the two participant event, and those who heard the intransitive sentence looked longer at the one participant
event. Fisher (1996) showed that preschoolers (3-year-olds and 5-year-olds), even when deprived of cues of subject and object identity (by using pronouns like ‘she’ and ‘her’ instead of using noun phrases that unambiguously pick out individuals in the world), were still able to reach the conclusion that verbs with two arguments and verbs with one argument label different events, indicated by their pointing towards the individual performing the action: in a complex event where a female individual A pulls along another female individual B who was seated in a wheeled dolly, children who heard ‘she is mooping her’ pointed to individual A more often as the performer of the MOOPING action than to individual B, whereas those who heard ‘she is mooping’ pointed to individual B more often.

Lidz, Gleitman & Gleitman (2003) studied the origin of this bias – whether this is an unlearned bias that reflects the grammatical architecture of all human languages or a generalization reached based on observations accumulated from the input. They provided two arguments for its being a universal unlearned bias: First, isolated deaf children who have no exposure to any language spontaneously invent home signs that demonstrate a similar mapping principle; specifically, invented gestures that include similar categories like nouns and verbs are combined into sentences that vary in the number and positioning of the noun phrases depending on the meanings of the verb (Feldman et al., 1978; Goldin-Meadow & Mylander, 1984). Second, 3-year-old children learning Kannada, a language in which certain morphological marking reliably indicates causativity (with a morpheme similar to the English “-ize”) whereas transitivity (the number of noun phrases) do not always have a causative meaning, still consistently rely on the less reliable predictor – number of noun phrases - to act out verb meanings; and the verbs are all known motion verbs for which there is a principled link between transitivity in structure and causativity in meaning.

In addition to Lidz et al. (2003), other researches that provide supporting evidence for PAM for children learning other languages include Naigles & Lehrer (2002) on 5-year-old French-learning children, Göksun et al. (2008) on Turkish-learning children, Arunachalam et al. (in press) on Korean-learning children, and
Lee & Naigles (2008) on Mandarin-learning children. In particular, Lee & Naigles (2008) considered Mandarin the ‘worst case scenario’ because it allows dropping of both the subjects and objects and it has no morphological cues to the verb argument structure; however, they demonstrated via an act-out task that 2- and 3-year-old children learning Mandarin still stick to the PAM, entertaining a causative meaning for a familiar intransitive verb when a post-verbal NP is added, and entertaining a non-causative meaning for a familiar transitive verb when the post-verbal NP is deleted.

Previous literature, including Lidz, Gleitman & Gleitman (2003)’s study on Kannada, which is also an object pro-drop language, therefore, suggests being an object pro-drop language may have no impact on acquisition. However, plenty of previous studies document that zero anaphors serve distinct functions from full NPs and overt pronouns, and are in different distributions as well: zero anaphors are less specific in reference compared to full NPs and overt pronouns, and are therefore used to refer to antecedents that are more accessible (Gordon & Hendrick, 1998; Ariel, 1990, 1991; Givón, 1983; inter alia). In a pro-drop language, dropping or not dropping an NP argument is not random, but is motivated by pragmatic felicity considerations. Given this, we suspect the pro-drop / non pro-drop status of the input language may still have some influence on child learners’ acquisition, and the reason why it was not seen before is due to simplified event structure. And we will show in our experiment with more complex events that this factor may exert an influence after all.

3. An important distinction - two versions of PAM:

Before moving on, however, an important clarification needs to be made. Usually in talking about PAM we assume that the event described by the clause is exactly the event described by the verb. No distinction needs to be made, in all above reviewed experiments, because the predicate in the testing clause is simple, comprising just a single verb. For example, the sentence “John pounded the dough” describes an event of pounding, and this is exactly the event of which the verb “pound” is a
predicate. However, not every clause has a simple predicate. In this paper our concern is clauses with complex predicates, resultatives such as “pound flat” in “John pounded the dough flat”. Therefore, concerning the question about the logical form of the complex clause type and the question of how to apply PAM, a distinction needs to be made, between a Word-based PAM which we believe is what most researchers in the literature are entertaining and thus the ‘standard view’, and a Sentence-based PAM\(^1\) (see below for definitions).

**W-PAM:** The clause has an argument for every participant of *each* event predicate within its verb phrase.

**S-PAM:** The clause has an argument for every participant of the event predicate given by its verb phrase.

S-PAM does not regulate the relation between the meaning and distribution of individual words; instead it regulates only the relation between the meaning of a clause and its argument structure. Therefore, the participants that need to be overtly realized as arguments are only those in this event identified by the clause (i.e. the VP). W-PAM, however, *does* care about individual verbs in the clause and thus requires each participant of each verb to be overtly realized as an argument. While simple clauses do not differentiate these two versions, the resultative case does. Take for example “John pounded the dough flat”. This mentions at least two events - an activity of pounding and a state of being flat. It is possible that the clause also mentions a third event, a change brought about by the pounding and ending with the flatness (Rappaport Hovav & Levin, 2001; Goldberg & Jackendoff, 2004; Williams, 2010). These events may share their participants, but sometimes they do not. And if they do not, as in what we will see in Mandarin resultatives, then the two versions of PAM become importantly different. Therefore, when hypothesizing child learners’ mapping strategy, we have to be careful about which events (hence which participants) our theory is referring to – the event of the clause, or the event of the verb.

\(^1\)S-PAM was never really considered by lexicalists like Fisher, Gleitman etc., who assume a lexicalist architecture. But it may be explicitly considered by Kako & Wagner (2001) and by Goldberg (1995), though perhaps not precisely in these terms.
While W-PAM guides learning in a way that regulates the relation between verb meaning and verb valence, S-PAM regulates the relation between clause meaning and clause valence. In most cases, S-PAM works in almost exactly the same way W-PAM does, because the event denoted by a sentence is usually named by the verb. The number and type of arguments in the clause is informative about the meaning of the sentence, which is informative about the meaning of the verb. For example, if the learner hears a sentence “John gorped the vase”, she builds a meaning with the logical form [gorp(e) & agent(e, John) & patient(e, vase)], and then uses this LF to find the event that this description satisfies.

From child learners’ perspective, they would not be able to differentiate between the event denoted by a clause or by a verb; all they hear from the input is some verb that they hear elsewhere, and the question is whether they would expect to hear the participant that usually occurs with the verb to always come together with it, no matter in what context (i.e. in a simple clause, or in more complex structures) – for example, whether or not child learners would expect to hear the thing being pounded to appear in the sentence every time they hear the verb ‘pound’. W-PAM would say “yes” to this question, while S-PAM would say “not necessarily”. According to S-PAM, if a clause is a predicate of POUNDING events, it should include an argument for what is pounded; but if a clause only has the verb ‘pound’ in it, it is not logically necessary that the clause is a predicate of POUNDING – it may instead describe an event related to POUNDING, perhaps one which has POUNDING as a ‘subevent’, for instance, a POUND-FLAT event. An event of POUNDING-FLAT is a change brought about by pounding, and ending with flatness. This change is related to the pounding, but presumably not identical to it\(^2\).

In complex-predicate cases like this, it is important to know whether child learners’ expectation is guided by PAM governing a verb or governing a clause. Resultative constructions provides a good test case to this question; and Mandarin RCs makes this case even more interesting, by allowing the patient of the event

\(^2\) Indeed it is not obvious that the POUNDING-FLAT event is also an event of POUNDING, since the one can be slow when the other is fast (Rappaport Hovav & Levin, 2001; Williams 2009).
denoted by the main verb to be absent in the sentence. The next section has more detailed discussion.

III. Resultative Constructions in English and Mandarin

1. The cross-linguistic variation:

Resultative Constructions (RCs) consist of a main predicate denoting the main event, a secondary predicate denoting the result of the main event, and a direct object. Following Williams (2008), we will call the main predicate *the means predicate* *(M)* and the secondary predicate *the result predicate* *(R)*. Semantically, RCs express a causative relation between the events denoted by M and R, and the direct object in RCs is the entity that undergoes the result state defined by R. For example, in (1a), the event denoted by M (i.e. wiping) causes the event denoted by R (i.e. cleanness), and the direct object (i.e. the table) enters the clean state as a result of M. In Williams’ (2008) terminology, the direct object NP *controls* R.

1. a. She wiped the table clean.
   b. *She wiped the cloth dirty. [Intended meaning: she used the cloth as the tool of wiping something, and as a result, the cloth became dirty]*

2. a. Ta ca ganjing le zhuozi.
   She wipe clean ASP table
   She wiped the table clean.
   b. Ta ca zang le mabu.
   She wipe dirty ASP cloth
   She wiped something with the cloth, and the cloth turned dirty.

3. a. She wiped the table.
   b. *She wiped the cloth. [intended meaning: wiping using a cloth]*

4. a. Ta ca le zhuozi.
   She wipe ASP table
   She wiped the table.
   b. *Ta ca le mabu.*
She wipe ASP cloth
She wiped something with the cloth.

English and Mandarin RCs have roughly the same structure, with a
difference lying in the order of R and its controller DO (direct object) – in English,
DO precedes R, whereas in Mandarin DO follows R. The RC structures in English
and Mandarin are schematized in (5) and (6) respectively (S: subject).

(5) S – M – DO – R
(6) S – M – R – DO

The crucial difference between English and Mandarin RCs that interests us
is the argument requirements of the means verb: In English, the patient of the
event denoted by the means verb must be syntactically realized, as the NP in DO
position. In contrast, in Mandarin, the patient of the means verb event does not
have to show up; instead, it is the patient of the whole clause (or, the resultative
predicate M-R) that takes the DO position. Sometimes the patient of the means verb
and the patient of the complex predicate happen to be the same entity in the world
- for example, the thing being wiped and the thing being wiped-clean are both the
table, while sometimes they correspond to distinct entities – for example, the thing
being wiped is the table whereas the thing being wiped-dirty is the cloth. It is when
the participant is not shared by the two events – event of the verb and event of the
clause – that English and Mandarin show diverging grammatical patterns, as in (1b)
and (2b); in particular, English requires the patient of the verb to always be present
in the sentence, whereas Mandarin is more flexible, in the sense that as long as the
patient of the clause shows up, it does not have to be the patient of the means verb
– it can be the instrument (e.g. the cloth used as the tool of wiping) from the
perspective of the means verb event.

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3 In Mandarin, R immediately follows M, and M-R is sometimes analyzed as a complex predicate (Li,
4 We will only focus on cases where the means predicate is a transitive verb; cases where it is an
intransitive verb are not within our discussion (e.g. He cried his throat hoarse).
Even though in RCs, Mandarin allows the noun phrase in the direct object position to be interpreted as the instrument of the event denoted by the means verb, it does not allow this interpretation in simple clauses, as in the contrast between (4a) and (4b). This is the same as in English; see the contrast between (3a) and (3b). This is not surprising, because the reason why Mandarin allows an instrument interpretation in RCs is because the instrument of the means event happens to be the patient of the complex predicate (i.e. the patient of the clause); in simple clauses, however, the patient of the verb and the patient of the clause are equivalent, thus disallowing the direct object NP to be interpreted as the event instrument.

The patterns in RCs and simple clauses in English and Mandarin are summarized in Table 1. In Williams (2008)'s terminology, when a verb is subject to the same argument requirements in simple clauses and RCs, it shows ‘uniform projection'; and thus English is classified as a language with the Uniform Projection Property (UPP), whereas Mandarin lacks this property⁵. We will show that this language-specific property may interact with the learning bias to generate expectations that vary from language to language.

<table>
<thead>
<tr>
<th>Simple Clause</th>
<th>Resultative Construction</th>
</tr>
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<tbody>
<tr>
<td><strong>Structure</strong></td>
<td><strong>Semantic Relation</strong></td>
</tr>
<tr>
<td>English</td>
<td>S – V - DO</td>
</tr>
<tr>
<td>Mandarin</td>
<td>S – M – DO – R</td>
</tr>
</tbody>
</table>

- Table 1 -

⁵ According to Williams (2007), Igbo, a language of southeastern Nigeria, demonstrates similar lack of UPP.
Here are more for more examples of Mandarin RCs; see (7)-(9). In 7a, 8a, and 9a, the direct object NP refers to the patient of the main verb's event; in 7b, 8b and 9b, the direct object NP is the instrument of the main verb's event, and it is also the patient of the clause's event.

(7) a. Ta qie sui le rou.
    She cut into-pieces ASP meat
    She cut the meat into pieces.

b. Ta qie dun le dao.
    She cut dull ASP knife
    She cut something with the knife, and the knife turned dull.

(8) a. Ta ti duan le shuzhi.
    She kick broke ASP tree-branch
    She kicked the tree branch and as a result the tree branch split.

b. Ta ti teng le jiao.
    She kick hurt ASP foot
    She kicked something with her foot and her foot was hurt.

(9) a. Ta hua hei le meimao.
    She drew black ASP eyebrows
    She drew her eyebrows black.

b. Ta hua tu le meibi.
    She drew blunt ASP eyebrow-pencil
    She drew (her eyebrows) with an eyebrow-pencil, and the pencil turned blunt.

2. Question in acquisition:

This cross-linguistic variation calls the simplistic formulation of the PAM hypothesis – the W-PAM – into question, because the Mandarin data obviously go against a word-based participant-to-argument matching. It is possible that all learners, including Mandarin-learners, start with W-PAM, getting started in the learning task strictly following participant-to-argument matching based on
individual verbs; however, eventually they have to overwrite this strong bias to learn the structures that are inconsistent with it (e.g. RCs that allow the absence of the patient of the means verb), and this overwriting process may be costly – the child whose expectation is guided by W-PAM may be massively confused when she hears a familiar transitive verb with no patient occurring with it, and if the W-PAM bias is very strong, they may have to conclude that the apparently familiar word is in fact not the word they thought it was.

Therefore, in face of the cross-linguistic data, it is worth asking whether the usually entertained W-PAM is indeed the correct formulation of the PAM hypothesis. Comparing English- and Mandarin-learning children’s acquisition of the resultative construction, therefore, serves as a good test case to the question.

3. Acquisition of RCs – previous work:

The literature on the acquisition of RCs is mainly about the onset of RC production, few has examined its comprehension in general. Bowerman (1982) reported that English-learning children started to produce resultative constructions at around age 2 (e.g. *wipe table clean*), but their productions at this stage were restricted to acceptable combinations heard in the input; they did not begin to produce novel constructions creatively until after 3.5 years of age (e.g. *pulled it unstapled – 3;8, washing me blind - 5;6*); and utterances that would be judged ungrammatical by English-speaking adults were found from children as old as 9 years (e.g. *the doggie bited him untied*). Chen (2006) looked at Mandarin-learning children’s development of verb compounding, including RCs, and showed an early onset of RC productions (as early as 1;9), which were nonetheless restricted to utterances modeled from the input; productive use of RCs did not begin until 2;6; and mastery of subtle semantic constraints (such as the strict ordering of component verbs, the constraint against specifying more than one path in a single clause, the constraints on the second predicate that are inherently agentative; see Chen, 2006, pp. 115-116) was not fully achieved as old as 8;1. These findings indicate that although production of RCs starts early in both languages, it
takes a long time for learners to fully master the subtle semantic constraints. In addition, Snyder & Stromswold (1997) demonstrated that English RCs are acquired together with a cohort of other constructions (including datives, verb-particle-constructions, put-locatives, causatives) as a group that is identified as a single syntactic class, the acquisition of which is roughly located at around 2 to 2.5 years of age.

Despite these findings on the onset of RCs in children’s production, few has examined its comprehension in general, nor the acquisition of particular argument requirements; and a cross-linguistic comparison in this regard, to our knowledge, has never been done. We would like to look at this issue with children of 2.5 years, which, according to previous studies, is likely to be the onset of RC production (though far from complete mastery), because looking at the onset might be informative to our inquiry about the origin of any bootstrapping strategy (e.g. the PAM).

IV. The Current Study

1. Questions:

Given the plausible other version of PAM, i.e. the S-PAM, and provided the Mandarin RC data that goes against a word-based mapping relation and seem to favor a clause-based relation, the current study aims to investigate the following primary question: Which formulation of the PAM hypothesis is the one that guides child learners as a learning bias, W-PAM or S-PAM? From the child learners’ perspective, this question can be framed in a slightly different way: Do child learners expect every participant of a verb to always appear in the sentence every time they hear that verb (i.e. W-PAM), or do they not care about individual verbs, but expect every participant of a clause to appear in the sentence?

As discussed above, this question can be best investigated in the context of some complex clauses where the event of the verb may differ from the event of the
clause, as opposed to simple clauses with one single verb. Therefore, this paper uses the acquisition of Resultative Constructions in English- and Mandarin-learning children as a test case to probe into this question. In particular, the current study asks: *For a given transitive verb, do English- and Mandarin-learning children expect the patient of the event denoted by the verb to always occur with the verb, no matter in what sentence structure, simple clause or resultative construction? Or, as long as the patient of the event denoted by the clause appears in the sentence, it is fine for them?* For this question, the two competing hypotheses are the W-PAM hypothesis and the S-PAM hypothesis.

In addition, this study also discusses two secondary questions. First, in a complex event where multiple two-participant events (both meet the same description of a transitive verb, two POUNDING events, for example) exist, upon hearing a transitive clause, which event do children selectively attend to? Do English- and Mandarin-children attend to different events, modulated by the pro-drop / non pro-drop status of the input language? As discussed earlier, a pro-drop language does not drop or keep an NP argument at random, but for certain pragmatic reasons, that is, a zero anaphora is used only when the referent is made clear and easily accessible. If the number of NP arguments is important for child learners to make inferences about verb meanings, and if pro-drop languages drops or keeps NP arguments in a particular pattern, we suspect being a pro-drop language may impact child learners’ interpretation of sentences in a different way than a non pro-drop language. This impact, however, cannot be seen in the design using simple event structures where a two-participant event and a one-participant event are cleanly cut out from the complex world, each clearly corresponding to a transitive verb and an intransitive verb, because in cases like this it is unnecessary to do any further analysis of the sentence and the event. We will show in our experiment with a more complex event structure that the pro-drop / non pro-drop status of the input language does exert influence on children’s interpretation.

Second, the ability to use PAM, whichever version of it, depends on the child learner building an accurate parse of the sentence; and their ability to build such a
parse may be dependent on their vocabulary knowledge. Therefore, we also look at the effect of vocabulary on children’s encoding of the sentence and thus their interpretation. We are not looking at general vocabulary size, but instead, at knowledge of the particular predicates occurring in the experimental sentences. We will show that knowledge of particular predicates predicts the growth of syntactic knowledge better than age does; and it impacts children’s encoding of the sentences in which the predicates occur.

2. Experimental design & stimuli:

One way to study the primary question, namely, whether or not child learners always expect the patient of a transitive verb to appear with it, is to manipulate the thematic role of the NP argument in the direct object position - patient or non-patient, and to see whether or not children allow thematic interpretation of the direct object NP to be something other than patient (e.g. the instrument of the verb’s event). With this logic, the experiment is designed as a noun-learning task, with a novel noun occupying the direct object position in the linguistic stimuli (e.g. a resultative sentence like “she bumped the teeg awake”), and meanwhile making possible an interpretation of the novel noun either the instrument or the patient of the event denoted by the main verb (e.g. instrument of BUMPING or patient of BUMPING). This ambiguity between the two interpretations is realized by making the non-linguistic stimuli a complex event in which two objects take part, one is the instrument and the other the patient of the event of the verb, but importantly, both can be the patient of the event of the clause (e.g. both the instrument and patient of BUMPING undergo the result state AWAKE). In this way, we can ask what thematic role child learners assign to the referent of that novel noun – patient (of the event of the verb) only, or, more flexible?
The non-linguistic visual stimuli comprise a set of complex causative events: in each event, there is a sub-event, the means event, where an agent (represented
by a human hand) uses an object (the instrument of the means event) to act on another object (the patient of the means event); and in another sub-event, which is the result state caused by the means event, the result event, both objects undergo a change of state that could be described by the same result predicate. See Figure 1 for an illustration of the design of the complex event, using the ‘bumping-awake’ example: 1a is the beginning state of the event, 1b a middle state, and 1c the end state. Accompanying the events are audio narratives of the displayed scenario, and the critical linguistic stimuli are sentences where the novel nouns are embedded.

The experiment uses a 2 (language) * 3 (condition) between-subject design. The two languages are English and Mandarin. The three conditions are resultative condition (RES), simple clause condition (SC), and control condition (CON), which differ from each other only in the linguistic stimuli presented: In RES and SC conditions, the novel noun occupies the direct object position of a resultative sentence and a simple transitive clause, respectively; and in the CON condition, the novel noun appears in a linguistically-neutral frame; see (10) for example sentences. We look at child participants’ assignment of thematic role to the novel noun argument: the patient of the means event or the instrument.

(10) RES: She bumped the teeg awake.
   SC: She bumped the teeg.
   CON: It’s a teeg.

For each participant, there are 7 trials, each with a different causative event corresponding to two predicates (one means predicate, one result predicate); so there are 14 predicates appearing in the experiment in total, and they are: wipe and clean, pound and flat, scratch and rough, push and crooked, poke and red, rub and black, and bump and awake. All participants in all conditions see the same set of 7 events, but hear different sets of 7 sentences: in each trial, both of the two predicates occur within a resultative frame in RES condition; only the means predicate occurs in SC condition, within a simple clause frame; and neither of them occurs in CON condition's neutral frame. The two objects in each trial were
designed to be of as equal novelty as possible such that children would not easily assign the novel noun to one of the objects because he/she already has a name for the other. The 7 events and the corresponding 14 predicates were selected carefully based on the following criteria: a) the result event denoted by the result predicate is a likely state for both objects to enter\(^6\); b) the action of the means event is picturizable and is properly described by the means verb; c) the combination of the means and result predicate respects the semantic constraints of resultative construction in each language. Importantly, we did not on purpose select 14 predicates that are familiar to most children at this age, because a bit variation of difficulty would allow us to study the role of predicate knowledge in child learners’ encoding of the sentence.

This design, while aiming to address the primary research question – which formulation of PAM is at work in the context of complex predicates, at the same time also allows room for a discussion about the secondary questions. First, the complex event structure made possible by this design allows us to examine possible influence of other cues than number of NP arguments, the pro-drop feature of the input language in particular. For a simple transitive clause like ‘she bumped the teeg’ (in the SC condition), the event picked out (verb’s event and clause’s event are equivalent) is not straightforward in the complex scenario: the-agent-bumping-the-patient event can be a BUMPING event; and, because it is designed that the instrument object also undergoes a change of state, the instrument object may also be construed as a patient of the action, although probably not the most canonical construal, but imaginable; therefore, after PAM zooms in on the two-participant event category, there are two possible two-participants events that both meet the description of the verb/clause. Which event the child learner attends to, therefore, determines which object she thinks is the referent of the novel noun. Importantly, the direct object novel noun is overtly

\(^{6}\)We understand it is very hard to make the likelihood of entering the result state equal for the patient and instrument, because it is usually expected and thus pragmatically more felicitous for the patient of the means event to undergo some change of state while maintaining the state of the instrument as original. But we tried our best to make the result state to be a likely state for the instrument to enter.
expressed in the sentence, which may, on top of PAM, affect the attention of children learning Mandarin, a pro-drop language for which overt mentioning of the object is necessitated only under certain circumstances, for example, when the reference is not clear or accessible. Second, predicates of various levels of familiarity allow us to study the role of predicate knowledge – how predicate knowledge work as a predictor for general syntactic knowledge development, and how predicate knowledge affects child learners’ encoding of the sentences.

Before running the experiment on child participants (Experiment 2), we first conducted the experiment on adult participants, using the same materials, for control purposes. See the next section for more detail.

3. Experiment 1:

Experiment 1 is a control experiment conducted on adult English- and Mandarin-speakers, with the following two goals: a) to test how good the above-discussed design taps into the facts of the adult grammars, particularly the variations in resultative constructions; and b) to get an idea about which two-participant event, out of the two available ones described by the simple transitive clause, is the most canonical one for adults.

3.1. Participants:

A group of adult participants were recruited for control purpose. The group comprised 24 English-speaking adults and 24 Mandarin-speaking adults, 8 participants in each condition. English adults were college students enrolling in introductory-level courses of Linguistics Department at the University of Maryland, who participated in this experiment as part of the course requirement; and Mandarin adults were recruited from the Chinese community around campus, for whom $5 was offered as monetary reward.
3.2. Materials and Method:

We tested adult participants with the experimental materials discussed in Section 2 (the same as that for children) in the form of multiple choice questions.

3.3. Procedure:

An adult participant either came to the Cognitive Neuroscience of Language Lab on campus or met with the researcher at some low-distraction place of their convenience. The experiment involved watching an animated video via the computer screen. The video consisted of seven trials, each of which was a short video having two novel objects involved in a causative event. Each trial included the following parts: a) familiarization with two objects by presenting them one after another, b) a causative event where an animated human hand was using one object to act upon the other, and both of the objects underwent some change of state and entered the same result state, and c) the two objects were presented widely apart on each side of the screen, in their end states (the states after change). Part b) was crucial because it introduced the novel noun in linguistic stimulus that varied in structure across conditions, which we expect would affect the participant’s choice during test in different ways: in RES condition, the linguistic stimulus was a resultative sentence (e.g. ‘Look, she bumped the teeg awake!’); in SC condition, it was a simple clause (e.g. ‘Look, she bumped the teeg!’); and in CON, it was a linguistically-neutral one (e.g. ‘Look, it’s a teeg!’) that by itself should not have any syntactic influence on the participant’s choice.

At Part c), three questions were asked about the reference of the novel noun – Question 1: ‘Where’s the [novel noun]?’ Question 2: ‘Which one’s the [novel noun]?’ Question 3: ‘Find the [novel noun]!’. Adult participants were asked to provide an answer to the question ‘which one is the [novel noun]’ for each trial, by circling one of the following three options on the answer sheet: A. the object on the left, B. the object on the right, and C. either. The side where the patient and instrument object occurs is counterbalanced. There was no requirement on timing for adults to circle their answer – they could do it any time and could also change
their mind during the experiment; and although they were asked three questions, they were instructed to give only one answer to each trial.

The adult control experiment evaluates how good this experiment design taps into the facts of the adult grammars - with the ‘either’ option available, choosing A implies disallowance of B and vice versa, but choosing C implies allowance of both. The results we collected truly reflects the cross-linguistic variation, proving the design valid; see the Section 3.6. Results, for more detail.

3.4. Measurement:

In this experiment, each adult gave seven answers (one for each trial). Each option is coded as ‘patient’, ‘instrument’ or ‘either’, and the proportion of each option out of the 7 trials is taken as the dependent variable; so each participant has three measures: proportion of ‘patient’ option (number of trials the participant chose ‘patient’ divided by 7), proportion of ‘instrument’ option, and proportion of ‘either’.

3.5. Predictions:

If the design succeeds in tapping into the adult English and Mandarin grammars about resultative constructions, then we would expect to see a large proportion of ‘either’ choice among Mandarin-speaking adults and a large proportion of ‘patient’ choice among English-speaking adults in the RES condition. For the SC condition, adults’ choices will be indicative of which event they attend to more as the one picked out the simple transitive clause (or the transitive verb), and thus telling us which event is the most canonical candidate for a simple transitive clause.

3.6. Results:

The results revealed a pattern consistent with the adult grammar in each language: In RES condition, Mandarin-speaking adults chose the indeterminate option ‘either’ (75%) significantly more than English-speaking adults did (19.6%), and also more often than the other two options as well (‘patient’: 21.4%, ‘instrument’: 3.6%); the dominant choice of English-speaking adults, in contrast was ‘patient’ (78.6%). This
pattern is consistent with the observation that Mandarin grammar allows the direct object of a resultative sentence to be interpreted as the *patient of the clause*, which can sometimes be identical as the patient of the means event and sometimes as the instrument that undergoes the change of state described by the result predicate; and it is also consistent with English grammar that only allows the direct object NP to be interpreted as the *patient of the verb*. Interestingly, though, among the 25% of Mandarin-speaking adults’ non-‘either’ option, ‘patient’ took up 21.4% whereas only 3.6% for ‘instrument’. This pattern suggests a preference towards the patient object over the instrument object. In SC condition, both Mandarin- and English-speaking adults most often chose the ‘patient’ option (Mandarin: 89.3%, English: 82.1%), in accordance with the grammars of both languages. In CON condition where the linguistic stimuli is not expected to exert any influence on people’s interpretation, we observed exactly this expected pattern: both English- and Mandarin-speaking adults chose ‘either’ for most of the time (Mandarin: 89.3%, English: 80.4%), and the rest small proportion is almost equally distributed between ‘patient’ and ‘instrument’ for both languages (Mandarin – ‘patient’: 5.3%, ‘instrument’: 5.3%; English – ‘patient’: 10.7%, ‘instrument’: 8.9%). See Figure 2 (a for Mandarin, b for English) for illustrations of the above observations.
3.7. Discussion:

The above results truthfully reflect the fact we know about the typological difference between Mandarin and English resultative constructions, proving the design a valid tool to investigate children’s grammatical knowledge in resultatives. In addition, adults’ choices in the SC condition suggest that the most canonical two-participant event for the simple transitive clause is the one where the designated patient is the event patient, rather than the one where the designated instrument is the event patient, which is not surprising. Their attention, obviously, was not affected by the pro-drop/non pro-drop status of the input language. We will see whether child participants would think the same in Experiment 2.

4. Experiment 2:

With adult control data proving the design valid, we conducted Experiment 2 on child participants.

4.1. Participants:

There were 57 English-speaking and 39 Mandarin-speaking child participants, all
within the age range of 30;00 to 34;00. The English group was recruited through University of Maryland Infant and Child Studies Database, and the Mandarin group was recruited via one of the following two sources in China: a) Laboratory of Developmental Studies, Dept. of Psychology, Beijing University, and b) Kmy Baby Early Childhood Center. Out of all child participants, 21 (10 English, 11 Mandarin) were excluded from the data sample for the following reasons: failure to complete the task, experiment error and/or equipment failure, and improper communication between parent and child. The detailed composition of participants included in analysis is summarized in Table 2.

<table>
<thead>
<tr>
<th></th>
<th>English</th>
<th>Mandarin</th>
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<tr>
<td></td>
<td>M</td>
<td>F</td>
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<tr>
<td>RES</td>
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<td>CON</td>
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<td>SC</td>
<td>9</td>
<td>8</td>
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<tr>
<td>Total</td>
<td>29</td>
<td>28</td>
</tr>
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- Table 2 -

4.2. Materials and Method:

We adopt the Preferential Looking Paradigm (PLP), the basic idea of which is: after a short period of familiarization (the content of which varies based on the research question being asked), children are presented with two images or events on both sides of a big television screen accompanied with a test utterance, and their looking preference (i.e. looking more towards one image or event over the other) is taken as indicator of their interpretation of the test utterance. This design is based on findings that children generally look more to an image or event that matches their interpretation of the audio than to a non-matching one (Spelke, 1979; Golinkoff, Hirsh-Pasek, Cauley & Gordon, 1987; Hirsh-Pasek & Golinkoff, 1996). This method has been successfully used for learners from as young as 2~6 months (Tincoff & Jusczyk, 1999, with 6-month-olds; Kuhl & Meltzoff, 1982, with 4-month-olds; Baier et al., 2007, with 2-month-olds) to as old as 3 years (Naigles, 1998).
In our experiment, in the familiarization phase, we present child participants the complex events with the two objects involved, accompanied by linguistic narratives containing the novel noun, the structure of which varies across conditions; and at test, we display the two objects each on one side of the screen, with the side each object appears on counterbalanced across trials, and we ask ‘which one is the [novel noun]’. The experiment materials used for children and that for adults were exactly the same.

4.3. Procedure:

For the English group of child participants, a child was escorted by his/her parent to the Project on Children's Language Learning Lab on campus, where a researcher played with the child and made him/her comfortable and another researcher explained the experimental procedure to the parent and received the parent’s consent. Parents were also asked to fill out a vocabulary list measuring children’s productive vocabulary, including the 14 predicates particularly used in this experiment; they could either fill it out in the lab or beforehand at home. When the child was ready, we invited the child together with the parent to the test room, where the child was asked to sit in front of a large TV screen, either in a highchair or in the parent’s lap. The parent was asked not to communicate with the child about the experiment. Then, the researcher walked out of the test room and the experiment began.

The experiment involved the child watching an animated video played on the TV screen in front of her, and we videotaped the direction of the child’s gaze via a camera mounted on the wall. The video consisted of seven trials, each of which was a short video having two novel objects involved in a causative event. Each trial had a familiarization phase and a test phase, the boundary between which was unbeknownst to the child; in other words, we made sure the child felt he/she was watching a fun video instead of being tested. The familiarization phase includes a) familiarization with two objects by presenting them one after another, and b) a causative event where an animated human hand was using one object to act upon
the other, and both of the objects underwent some change of state and entered the same result state. Part b) of this phase was played twice, transitioned by the audio ‘let’s see that again!’; this part was crucial because it introduced the novel noun in linguistic stimulus that varied in structure across conditions, which we expect would affect the child’s performance during test in different ways: in RES condition, the linguistic stimulus was a resultative sentence (e.g. ‘Look, she bumped the teeg awake!’); in SC condition, it was a simple clause (e.g. ‘Look, she bumped the teeg!’); and in CON, it was a linguistically-neutral one (e.g. ‘Look, it’s a teeg!’) that by itself should not have any syntactic influence on the child’s gaze. The test phase began after this, in which the two objects were presented widely apart on each side of the screen, in their end states (the states after change), and three questions were asked about the reference of the novel noun – Question 1: ‘Where’s the [novel noun]?’, Question 2: ‘Which one’s the [novel noun]?’, Question 3: ‘Find the [novel noun]!'; there were an at least 2-second interval between questions. The whole video was about 7-minutes long. Each visit usually took half an hour, including playtime, consenting and post-experiment parent debriefing.

The procedure for the Mandarin group was roughly the same, except for the venue of experiment: The child participant was escorted by the parent (if weekend) or the teacher of his/her class at school (if school day) to the Laboratory of Developmental Studies of the Psychology Dept. at Beijing University, or a pre-arranged test room at Kmy Baby Early Childhood Center, depending on how the child was recruited; minor equipment difference was involved.

4.4. Measurements:

4.4.1. Measurement of performance in the task:

The dependent variable commonly used in the Preferential Looking Paradigm is the average proportion of look towards the target within a selected window. The selection of such a window may vary from study to study. The traditional analysis Golinkoff and colleagues (Golinkoff, Hirsh-Pasek, Cauley & Gordon, 1987) used a 6-second window starting from the offset of the target word (or disambiguation
point). This analysis, however, was questioned by recent research of Fernald and colleagues on real-time measures of the time-course of children’s gaze patterns in response to certain linguistic stimuli (Fernald, Zangl, Portillo & Marchman, 2008), which found a sign of rapid processing toward the end of the second year of age: In several studies using (a variation of) the PLP examining infants responses to familiar words as a function of different prosodic features, they found that 24-month-olds performed worse than 18-month-olds when their look time was averaged over a 6-second window, countering the predicted improvement in word recognition; when they used a window of 4 seconds, however, the data begun to look more towards the predicted pattern; and eventually, a window of 2 seconds revealed a large proportion of look towards the target (80%) for 24-month-old and a smaller proportion (60%) for 18-month-olds. This manipulation in window selection shows that the traditionally used window may underestimate older children’s real knowledge by failing to capture their correct and yet fast-fading responses due to rapid processing. Therefore, a window of 2 seconds has now been adopted for most of PLP studies for children above 2 years of age; and using a window from the onset of the disambiguation point is another manipulation aiming to capture children’s rapid responses.

In this study, we adopt the well-tested 2-second window as our way of data reduction. We measure the average proportion of look towards each object on the screen, i.e. the patient and the instrument of the means event, within the 2-second windows after the disambiguation point – the onset of the novel noun in each of the first test questions (i.e. ‘Where’s the [novel noun]?). We use the proportion of look towards the patient object out of the total look towards either object as the dependent variable: i.e. looks to patient / (looks to patient + looks to instrument). For example, if within the 2-second window, that is, 60 frames, the participant looked to the patient object for 30 frames and to the instrument object for 20 frames, and was not attending to either for 10 frames, then the value of the dependent variable for this participant is going to be 30 / (30+20) = 0.6. This measure considers the relative strength of attractiveness of the two objects, the
value of which will always fall in the range of $[0, 1]$: a value above 0.5 indicates more time spent looking towards the patient object, a value below 0.5 indicates more time spent looking to the instrument object, and a value near 0.5 indicates roughly the same amount of looking time. Note that when I am using the word ‘patient’, without further specification, it means the patient of the event denoted by the means verb.

4.4.2. Measurements of predicate knowledge:

It is well documented in the developmental literature that children sometimes reach the same developmental stage at slightly different ages and children of the same age may demonstrate different performance patterns of the same task depending on their individual level of development. Therefore, while the above-mentioned primary measurement indexes participants’ performance in the experiment, it is also important to measure individual differences. In this study, we are particularly interested in looking at how child participants’ performance varies as a function of their knowledge of the particular predicates in the stimuli sentences. For this purpose, we measure knowledge of the 14 predicates used in the current study for each participant, based on parental report. For the English group, with the availability of a widely-used measurement of general vocabulary size – the MacArthur Communicative Development Inventories (Fenson et al., 2000), we also asked parents to fill out the a vocabulary list based on the Short Form Versions of the MacArthur CDI. This is a measurement of children’s productive (in contrast to receptive) vocabulary. And not surprisingly, we found significant correlations between general vocabulary size and knowledge of the 14 particular predicates; see Section 4.6. Results, for more details.

4.5. Predictions:

4.5.1. On primary research question:

The primary research question, is, to repeat: for a given transitive verb, are English- and Mandarin-learning children expecting the patient of the event denoted
by the verb to always occur with the verb, even in the resultative construction, or are their expectations not specifically tied to the verb, but to the clause? The hypotheses concerning this question give the following predictions in the context of the current experiment design, particularly concerning the RES condition.

The **W-PAM hypothesis** says both all children would expect the patient of *the verb's event* to always appear in the sentence, thus predicting child participants, regardless of the input language (English or Mandarin), hearing a resultative sentence would spend more time looking at the patient object than at the instrument object. This hypothesis would also predict children in hearing a simple transitive clause (i.e. in the SC condition) would also look more towards the patient, regardless of the language group.

The **S-PAM hypothesis** says that all children would expect the patient of *the clause’s event* to always appear in the sentence. Since either the patient object or the instrument object can be construed as the patient of the clause’s event, this hypothesis predicts child participants, regardless of the input language (English or Mandarin), hearing a resultative sentence would spend equal amount of time looking towards the two objects.

There is still a third possibility, however. The learning bias, no matter in what formulation, is going to interact with other language-specific properties that are already figured out by a certain age (e.g. word-order). Recall from Section III.1. that an important difference between Mandarin and English is the absence/presence of UPP (Uniform Projection Property), which dictates whether a verb has the same argument requirement across structures. If, by 2.5 years of age, children already figure out this language-specific property, then, it is going to interact with the learning bias, resulting in different behavioral patterns between the two language groups. Let’s call this third possibility the **PAM plus UPP hypothesis**. The specific prediction of this hypothesis is going to depend on which version of PAM is at work. If it is UPP on top of W-PAM (i.e. **W-PAM + UPP**), then it would make no difference in predictions: English-learning children upon hearing a
resultative sentence would look more towards the patient object because of W-PAM, and this is consistent with UPP, because the verb cross-structurally requires a patient NP; and Mandarin-learning children would also look more towards the patient object, and this does not violate its lack of UPP, because lack of UPP does not regulate verb’s argument requirements in different structures must be different. If, on the other hand, it is UPP on top of S-PAM (i.e. S-PAM + UPP), then it would predict the following: English-learning children upon hearing the resultative sentence would look more towards the patient object, because even though both objects are compatible with the expectation generated by S-PAM, the additional constraint UPP in English dictates that the verb requires a patient NP in a resultative sentence as it does in a simple transitive clause; Mandarin-learning children, in contrast, would spend equal amount of time looking towards either objects, because Mandarin lacks UPP and this additional constraint does not exert any additional influence.

4.5.2. On the effect of pro-drop:

This study also looks at possible impact of the pro-drop / non pro-drop status of the input language on children's interpretation. Specifically, in a complex event where multiple two-participant events exist, upon hearing a simple transitive sentence, which event do child learners attend to, and is their selective attention modulated by the pro-drop/non pro-drop status of the input language?

If being a pro-drop language does not affect Mandarin-learning children’s interpretation, then, they would attend to the same two-participant event as English-learning children do, which is likely to be the most canonical event – the one in which the designated patient object is the event patient (e.g. in Figure 1, the bumping event of which the bear-like thing is the patient), as for most adult participants (See Section IV. 3.). If, on the other hand, Mandarin-learning children do pick up on the pragmatic effect of zero anaphora, as documented in previous works - only dropping the object (i.e. using zero anaphora) when the referent is clear and accessible, which is usually expected; then, overt mentioning of the object
(in the form of a novel noun) implies something unusual and contrary to expectation is being talked about. Therefore, for Mandarin- but not English-learning children, the non-canonical event - the event where the designated instrument is construed as the event patient (e.g. in Figure 1, the fish-like thing, also designated by the experimenters to be the instrument, may be construed as the patient of bumping by virtue of itself entering a change of state) - might be attended to more often, by virtue of its being unexpected; therefore, more time spent looking towards the instrument object will be observed for Mandarin-learning children.

4.5.3. On the effect of predicate knowledge:

If knowledge of particular predicates in the stimuli sentences do play a role in children’s building an accurate parse of the sentence, then we would expect to see individual differences varying with predicate knowledge, but only in the RES and SC conditions where the particular predicates occur, but not in the CON condition where the sentence does not contain any of the predicates; further more, we would expect to see only knowledge of the main verb (i.e. the means verb) to have an impact in the SC condition, but knowledge of both the means verb and the result predicate to have an impact in the RES condition.

4.6. Results:

4.6.1. Overall analysis:

Figure 3 shows the overall pattern obtained for the whole sample, with the three conditions plotted on the x-axis, language as the grouping factor, and y-axis plots corresponding values of the dependent variable, averaged across all participants. Recall, from Section 4.4.1. that a value of the dependent variable above 0.5 indicates more time spent looking towards the patient whereas a value below 0.5 indicates more time spent looking towards the instrument. As Figure 3 shows, overall, the average proportion of look towards patient seems to hover around 0.5 for both languages in all conditions; but in SC and RES conditions, it seems that
English-learning children spent more time looking towards the patient than Mandarin-learning children did, while the two language groups seem to demonstrate similar patterns in CON condition.

A 2 (language) by 3 (condition) independent-groups analysis of variance confirms this observation: there is no main effect of language, $F(1,90) = 1.29, p = 0.26$, or condition, $F(2,90) = 0.16, p = 0.85$; but the interaction between language and condition is significant, if using the 10% level of significance, $F(2,90) = 2.51, p = 0.09$.

![Whole Sample](image)

- Figure 3 -

### 4.6.2. Individual differences modulated by predicate knowledge:

A closer look at the composition of the sample reveals great individual differences in terms of vocabulary knowledge, indexed by knowledge of the particular 14 predicates in the experiment. For the English group, predicate knowledge ranges from only knowing 2 to knowing all 14 predicates (mean = 9.13); and for the Mandarin group, it ranges from 4 to 14 (mean = 9.67). In addition, with the availability of the English group’s productive vocabulary measures from MacArthur CDI, we looked at the correlation between general vocabulary size and our measure of predicate knowledge, as well as that between general verb size and predicate
knowledge, and found very strong correlations, see Figure 4a and 4b. Pearson’s correlation measure confirmed there was a statistically significant, strong positive relationship between vocabulary size and number of predicates known, $r(51) = 0.81$, $p < 0.01$; and there was also a statistically significant, strong positive relationship between verb size and number of predicates known, $r(53) = 0.87$, $p < 0.01$. These strong correlations between measurements of general vocabulary development and measurement of particular predicate knowledge suggest it is reasonable to use predicate knowledge as an index of individual differences of language development.
Even though we found an interaction effect between the two independent variables, given the large individual differences in predicate knowledge in this sample, it is possible that some stronger effects are hidden in the overall effect. To examine this possibility, we should first take a look at how individual performance scores are distributed across the range of predicate knowledge. Figure 5 (a-f) plot the scatterplots of the relation between a participant’s predicate knowledge and that participant’s value of the dependent variable, in each condition, for each language group.
- C -

- d -
From Figure 5, we observe the following patterns: Overall, Figure 5 confirms our intuition that there are huge individual differences in performance in the task, and these differences do not seem to be random, but rather, are modulated by individual predicate knowledge (at least in some conditions), which can be used as
an appropriate index for individual language development. Specifically, for the English group, in SC and RES conditions, it looks like higher predicate knowledge is correlated with more time spent looking towards the patient. For the Mandarin group, in the SC condition, interestingly, higher predicate knowledge is correlated with less time spent looking towards the patient; and in the RES condition, it seems that children with higher predicate knowledge spent roughly equal amount of time looking towards either object whereas those with lower predicate knowledge's looking pattern was not regular. In contrast, in the CON condition for both language groups, no clear looking pattern was observed, nor modulated by predicate knowledge.

Pearson's correlation analysis shows a statistically significant, strong positive relation between the dependent variable and predicate knowledge for SC condition in the English group, \( r(15) = 0.74, p < 0.01 \); a statistically significant, strong negative relation for SC condition in the Mandarin group, \( r(12) = -0.88, p < 0.01 \); and a statistically significant, strong positive relation for RES condition in the English group, \( r(15) = 0.79, p < 0.01 \). In contrast, there is no strong correlation for CON condition in the English group, \( r(20) = -0.20, p = 0.37 \), nor in the Mandarin group, \( r(8) = -0.19, p = 0.61 \). These all confirms the above observations. However, this relation for RES in Mandarin is not strong, \( r(13) = 0.07, p = 0.81 \). But we think the lack of correlation should not be explained away by simply stating that predicate knowledge does not exert any influence. To the contrary, the scatterplot in Figure 5e shows a clear division of performance pattern between children whose predicate knowledge is higher and lower than 10; specifically, those higher than 10 seem to be close to 0.5, and those lower than 10 seem to be equally distributed above 0.5 and below 0.5. This distribution, we believe, is indicative of a predicate knowledge effect on Mandarin-learning children’s performance in the RES condition.
4.6.3. Analysis by predicate knowledge split:

The individual differences observed in the scatterplots (Figure 5) strongly suggest that the overall effect (Figure 3) may hide some stronger effects due to individual scores going towards different direction cancelling each other out. To examine the hidden effects, we split the whole sample by median predicate knowledge within each condition per language group. The composition of the sub-groups based on this split and the corresponding median values are summarized in Table 3. Figure 6 illustrates the results of the subgroups: the group with high predicate knowledge (number of predicates known above median) in Figure 6a, and the group with low predicate knowledge (number of predicate known below median) in Figure 6b.

<table>
<thead>
<tr>
<th></th>
<th>English</th>
<th>Mandarin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>high predicate</td>
<td>low predicate</td>
</tr>
<tr>
<td>SC</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>RES</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>CON</td>
<td>12</td>
<td>10</td>
</tr>
</tbody>
</table>

- Table 3 -

![High predicate knowledge group](chart.png)

- a -
Figure 6 clearly shows different patterns between the two subgroups. For the group with higher predicate knowledge, basically the same pattern as in the whole sample is observed, but with a much larger effect: in both SC and RES conditions, English-learning children spent more time looking to the patient than Mandarin-learning children did; in addition, compared to the chance level (i.e. a value of 0.5), English-learning children in both SC and RES conditions looked more towards the patient than towards the instrument, while Mandarin-learning children looked more to the instrument in the SC condition but equally to the two objects in the RES condition. Both language groups in the CON condition showed a looking pattern around chance.

A 2 (language) by 3 (condition) by 2 (predicate knowledge group) independent-groups analysis of variance reveals a three-way interaction between the three factors, $F(2, 83) = 4.45, p = 0.02$. Since the three-way interaction is hard to interpret, we also conducted a 2 (language) by 3 (condition) independent-groups analysis of variance for each predicate knowledge group. For the high predicate knowledge group, there is a main effect of language, $F(1, 45) = 11.70, p < 0.01$; no
main effect of condition, \( F(2, 45) = 1.49, p = 0.24; \) and an interaction between language and condition, \( F(2, 45) = 8.49, p < 0.01. \) But for the low predicate knowledge group, there is no main effect of language, \( F(1, 38) = 1.50, p = 0.23; \) no main effect of condition, \( F(2, 38) = 1.14, p = 0.33; \) and no interaction, \( F(2, 38) = 0.27, p = 0.76. \)

4.6.4. Trial analysis:

A trial analysis further strengthens the observation that individuals’ performances are modulated by their predicate knowledge. We assign each trial to one of the following four trial types: a) trials for which both the M predicate and the R predicate are known by the participant, coded as “M=1, R=1” type; b) trials for which only the M predicate is known but R is not known, coded as “M=1, R=0” type; c) trials for which only the R predicate known but M is not known, coded as “M=0, R=1” type; d) trials for which neither the M nor the R predicate is known, coded as “M=0, R=0” type. Figure 7a (English) and Figure 7b (Mandarin) illustrate the results based on this grouping of trial types.
From Figure 7, we observe the following patterns. For the English group, children's performance in SC condition seems to depend mostly on knowledge of the M predicate and not affected much by R predicate knowledge; in particular, when they knew the M predicate, they spent more time looking to the patient, and when they did not know the M predicate, they looked more towards the instrument, regardless of R predicate knowledge. This is not surprising, because the R predicate did not occur in the linguistic stimuli in SC condition. English-learning children's performance in RES condition depend on knowledge of both the M and R predicates; in particular, when both predicates were known, more time was spent looking to the patient, and when at least one of the predicates was not known, more time was spent on looking to the instrument instead. For the Mandarin group, children's performance in SC condition, again, was modulated only by M predicate knowledge, but an opposite pattern to the English group in SC condition was observed: when M was known, the instrument object was attended to more often, and when M was not known, the patient object was attended to more often, regardless of R knowledge. Mandarin-learning children's performance in RES condition, similar to the English group, seems to depend on both M and R
knowledge, but in a different way: knowing M or knowing R seem to exert a different influence on children’s performance, as illustrated by the different height of the second and third bar – more look towards the instrument when M was known but R was not known, and more look towards the patient when R was known but M was not known; moreover, when both M and R were known, Mandarin-learning children spent roughly equal amount of time looking towards the patient and the instrument. For the CON condition, both language groups do not seem to have different performance patterns modulated by different trial types.

4.7. Discussion:

4.7.1. On primary research question:

Is the Participant-to-Argument Matching as a learning bias operating on a word-based level (i.e. W-PAM) or on a sentence-based level (i.e. S-PAM)? If W-PAM, then learners guided by this bias would expect the patient of the event denoted by a transitive verb to always appear in the sentence together with the verb, not matter in what sentence structure, simple clauses or complex-predicate clauses like resultatives. If S-PAM, then, learners are not always constrained to expect the patient of the verb to appear in the sentence, but rather, are satisfied as long as the patient of the clause occurs. In the current experiment, the **W-PAM hypothesis** predicts children in RES condition for both languages would have spend more time looking towards the object corresponding to the patient of the verb’s event, whereas the **S-PAM hypothesis** predicts children in RES condition for both languages would look to either object for roughly equal amount of time, because both the objects are patients of the clause’s event.

The results showed overall in RES condition, English-learning children spent more time looking at the patient whereas Mandarin-learning children spent roughly the same amount of time looking at either object (Figure 3), and children with higher predicate knowledge maintained this pattern with a more salient effect (Figure 6a). These results are consistent with the cross-linguistic variation observed in adult grammars, namely, English requires the patient of the transitive
verb to appear in the sentence whereas Mandarin allows it to be absent in a
resultative sentence as long as the direct object NP refers to an object that is the
patient of the whole clause (and here, both objects can be the patient of the clause).
But the results are not consistent with either W-PAM or S-PAM hypothesis, because
both of them, being hypotheses about a learning bias, predict a uniform pattern
across languages.

Recall, however, a third hypothesis (i.e. **PAM plus UPP hypothesis**) that
takes into consideration the interaction of any learning bias with the language-
specific property – Uniform Projection Property. This hypothesis is based on the
assumption that English-learning children this age have already figured out English
has UPP and Mandarin-learning children this age also know Mandarin lacks UPP. If
the UPP status of the input language is known on top of W-PAM (i.e. **W-PAM + UPP**),
then the prediction is the same as that of W-PAM alone, because the additional UPP
constraint does not provide any more information for English-learning children,
and Mandarin-learning children are not constrained by UPP. This possibility,
therefore, is not consistent with current results. If, however, the UPP status of the
input language is known on top of S-PAM (i.e. **S-PAM + UPP**), then it well explains
the difference between languages: for children from both language groups, neither
object violated the expectation generated by S-PAM, but because English-learning
children knew English had UPP, their expectation was further constrained – the
verb required its patient to occur in resultatives, just as in simple clauses. There is
also evidence for the assumption that UPP has been figured out by this age:
English-learning children’s looking patterns are uniform across SC and RES
conditions, consistent with English’s possessing UPP; and Mandarin-learning
children’s looking patterns are not uniform across SC and RES conditions,
consistent with Mandarin’s lack of UPP.

4.7.2. On the effect of pro-drop:

Previous studies documented that child learners could use syntax as a ‘mental
zoom lens’ to zoom in on relevant part of the world – a transitive verb guides their
attention to a two-participant event and an intransitive verb to a one-participant event. In addition, previous studies on pro-drop languages (e.g. Lee & Naigles, 1998, on Mandarin; Lidz et al., 2003, on Kannada; inter alia) seemed to suggest no special impact of the input language’s pro-drop status on child leaners’ application of syntax as a bootstrapping strategy. But almost all of them used simple ‘snapshots’ of the complex world as the non-linguistic stimuli, pitting a clearly two-participant event against a clearly one-participant event. This manipulation, while simplistically controls for many variables and thus is ideal for laboratory settings, is not able to reveal what else, in addition to choosing from a one-participant and a two-participant event, the child learners need to do to attend to the appropriate part of the world, and what cues other than the syntax they rely on, in real-life settings. The design of the current study, by virtue of having a complex event structure, allows us to look at whether the pro-drop / non-pro-drop status of the input language has an influence, on top of the PAM bias.

Current results show that English-learning children in SC condition preferred the patient whereas Mandarin-learning children preferred the instrument, when their vocabulary barrier is minimized (Figure 6a). We think the different behavioral patterns across language groups may be due to the language-specific property – pro-drop or not. Object drop in Mandarin is so common that when the object is expressed overtly by the speaker, there must be a reason. Imagine a scenario where a person uses a hammer to hit a laptop; if the laptop breaks, a Mandarin speaker would probably drop the object and say (11); but if it is the hammer that breaks, a sentence that drops the object would be pragmatically infelicitous because it fails to deliver the meaning that is normally expected; in this case, a Mandarin speaker will have to say (12) to draw attention AWAY from the expected meaning. Let’s call this the Contrary Expectation Effect (CEE) of overt NPs in a pro-drop language. This is consistent with the documented observations that zero anaphora and full NPs / overt pronouns are distrusted differently – in the hierarchy of referent specificity, full NP is the most specific, followed by overt pronouns, then followed by zero anaphora; and anaphors that are more specific are
used to refer to antecedents that are less accessible (Gordon & Hendrick, 1998; Ariel, 1990, 1991; Givón, 1983; inter alia). Importantly, in Mandarin, whereas for human referents there is a 3-way choice among full NP, overt pronoun (equivalent to English “she/her” or “he/him”) and zero anaphora, the pronoun equivalent to English “it” is seldom overtly mentioned; so the choice for non-human objects is basically two-way, between full NP and zero anaphora. This reduction may further magnify CEE when overt NP is used. Therefore, when Mandarin-learning children heard an overt noun in a simple transitive sentence, and importantly, when the accompanying scenario contains something unexpected (i.e. the change of state of the instrument), they are not only willing to, but more likely to, entertain the non-canonical event construal; in other words, it is the overt appearance of the direct object that steers children’s attention away from the canonical patient to the unexpected patient (i.e. the designated instrument), resulting in more look towards the instrument object. English does not have pro-drop, therefore English-learning children naturally attend to the most canonical two-participant event and interpret the novel noun as the most ‘patient-y’ thing in the complex scene.

\begin{exe}
\item[(11)] da sui le
hit broke ASP
Someone hit something, causing it to break.
\item[(12)] da sui le chuizi
hit broke ASP hammer
Someone hit something with the hammer, causing it to break.
\end{exe}

4.7.3. On the effect of predicate knowledge:

We found a very prominent predicate knowledge effect in this study, both in the subgroup analysis (Section IV. 4.6.3.) and in the trial analysis (Section IV. 4.6.4.). We have also shown that predicate knowledge, although measuring only knowledge of the 14 particular predicates used in the experiment, can be used as an index of general vocabulary development, based on its strong correlation with general vocabulary size measurements (Section IV. 4.6.2.). Our question concerning
predicate knowledge, however, specifically asks how predicate knowledge affects child learners’ encoding of sentences that already contains a novel word, and how this might interact with language-specific word-order differences.

To study the effect of predicate knowledge of sentence encoding, we classified all the trials into four categories based on knowledge of the M predicate and R predicate: both M and R are known, only M is known, only R is known, and neither of them is known. Current results reveal very different patterns among different trial types. Specifically, in SC condition where the linguistic stimuli is a simple clause containing only the M predicate, the performance of both language groups seem to depend on only knowledge of M, independent of R knowledge. This makes perfect sense, because a predicate that is not present in the sentence is not supposed to exert any influence in encoding that sentence. In this condition, English- and Mandarin-learning children show opposite patterns; and Mandarin-learning children’s instrument preference when they know the M predicates is explained in the previous section, by CEE (Section IV.4.7.2). But interestingly, within each language, the pattern when children know the M predicate and that when they do not know the M predicate are opposite. We do not have a perfect explanation for this, but here is our best guess: when children do not have enough vocabulary information to parse the sentence (there are two words in the sentence that they do not know, together with the novel NP), they choose to attend to something that is more interesting to them. But what counts as ‘interesting’ may differ for the two language groups: for English-learning children, it is the instrument entering a change of state that is most unexpected, therefore attracting most attention; for Mandarin-learning children, however, even though they do not know the verb, they heard a noun phrase being overtly mentioned, so their expectation about the referent of the overt noun is set to be the unexpected object—the designated instrument, in this case, what is interesting to them might be the other object.

For the RES condition, the two language groups demonstrate quite different patterns. For English-learning children, it is only when both M and R predicates are
known that they demonstrate looked more towards the patient, consistent with the subgroup analysis of the high predicate knowledge group. When either one of the two predicates is not known, they preferred the instrument. This pattern makes sense because in RES condition, children hear a resultative sentence that contains both the M and R predicates, and thus knowing the meaning of both is a necessary condition for them to correctly encode the sentence. In face of a vocabulary barrier (i.e. one or more of the two predicates is/are not familiar), however, child participants could not correctly parse the sentence, resulting in a preference towards the more unexpected and thus interesting part of the event, i.e. the instrument object. In addition, one may think when M is known but R is not known, children may treat the resultative sentence as a simple clause by simply ignoring the unknown predicate hanging at the end; interestingly, however, when M is known but R is not known, English-learning children looked more towards the instrument, which was not the same as in the SC condition when M is known (more look to the patient). This suggests that the unknown predicate at the end of the sentence clearly still plays some role, distinguishing the sentence (whatever it is encoded) from a simple transitive clause.

For Mandarin-learning children in the RES condition, when both M and R predicates are known, they were indifferent between the two objects, consistent with the subset analysis, which is not surprising. Intriguingly, when only M is known and when only R is known, we observe opposite patterns – more look to the instrument for the former case and more to the patient for the latter, and these opposite patterns seems to mirror those in the SC condition when M is known and when M is not known. We do not think this is a mere coincidence, but a result of knowing the language-specific word order of the resultative construction. Recall that although English and Mandarin RCs share the general structure, they have different word orders (Section III.1.), also repeated here – (a) is the English RC order, and (b) for Mandarin. For English, the M and R predicates are separated by the direct object NP, and is further separated by the inflectional morpheme ‘-ed’; in Mandarin, however, the direct object NP comes after both predicates, and
furthermore, the aspect marker 'le' is not intervening between M and R, but comes after them as well.

(a) S – M – DO – R
(b) S – M – R – DO

Therefore, whereas English-learning children encode the M and R predicates as separate verbs and thus still encode the sentence as a different one from a simple transitive clause, it is possible that Mandarin-learning children considered M-R as a single disyllabic verb rather than encoded it as a resultative predicate when part of it sounds unfamiliar. In addition, Mandarin-learning children encoded M-R as one verb, but determine its meaning based on the first syllable of it, namely, M; therefore, the M-R predicate is treated equivalently as a known main verb of a simple transitive clause when M is known (R is unknown), but treated as an unknown main verb when M is not known. This explains the parallel behavior pattern seen here in RES and in SC condition.

In sum, we observe a prominent predicate knowledge effect in the current experiment, both in a way of globally determining children’s performance – higher predicate knowledge indicates a more advanced developmental stage, and in a way of specifically affect the encoding of particular sentences. Importantly, predicate knowledge may affect encoding of sentence interactively with language-specific knowledge.

V. General Discussion

This paper investigates the widely discussed learning bias that guides child learners’ early verb learning, the Participant-Argument-Matching hypothesis under the context of complex clauses with a complex predicate. Complex predicates make visible an important distinction of two versions of PAM – the **W-PAM hypothesis** and the **S-PAM hypothesis**. This study attempts to investigate this distinction, by looking at 2.5-year-olds' interpretation of Resultative Constructions (RCs), in English and Mandarin. RCs are complex clauses comprising two predicates
– a means verb and a result verb, and English and Mandarin differ in their requirements of individual verb’s argument structure (the means verb, in particular), while both respecting the argument requirement of the clause. This cross-linguistic variation makes the acquisition of RCs an interesting test case for the two possible formulations of PAM.

Current results do not directly support either of the two hypotheses, because different behavioral patterns were observed in different language groups but both the W-PAM and S-PAM hypothesis predict a uniform pattern across languages. A third possibility is considered, that is, children this age already figured out the language-specific property – English has Uniform Projection Property whereas Mandarin does not, and this knowledge is utilized on top of PAM. Current results are consistent with the possibility of using UPP on top of S-PAM: S-PAM regulates the relation between clause meaning and clause valence and thus allows either object to be the potential referent of the novel noun, resulting in Mandarin-learning children’s equal look to the instrument and the patient; but with the additional UPP constraint, English-learning children expect the patient of the verb to always be present, thus looking more towards the patient.

We should also be aware of another possibility: children could have started with W-PAM as a learning bias, and at this age Mandarin-learning children already figured out the language-specific feature of resultatives, that is, complex predicate clauses like resultatives allow the patient of the verb to be absent. This is possible, but may be very costly compared to the above explanation: guided by W-PAM, Mandarin-learning children would generate a strong expectation that every time a transitive verb occurs, the patient of its event must also occur; then, when hearing resultative sentences where the patient of the verb is absent, they would be massively confused and might be forced to revise their hypothesis about the meaning of that familiar verb. Nevertheless, current results cannot by themselves tease apart these two possibilities: a) children all begin with S-PAM and then if they acquire a UPP language, they restrict appropriately; and b) children all begin with W-PAM and when they acquire a non-UPP language, they expand appropriately. To
answer this, further investigations are needed to specify what is the information that tells the learners whether they are learning a UPP language or not.

Additionally, the results of this study, from the SC condition in particular, suggests the pro-drop/non pro-drop status of the input language may still exert influence on child learners’ language acquisition, because this feature may modulate their attention in a complex world in different ways. Specifically, Mandarin-learning children’s more look towards the instrument is considered as a result of their attending to the non-canonical two-participant event upon hearing a transitive sentence. This is explained by the Contrary Expectation Effect of overt NP in pro-drop language. The finding that children hearing a simple transitive clause do not always attend to the most canonical two-participant event speaks against a simplistic formulation of PAM – the child learner can just look at the world, hear a sentence, find in the world here is a patient here is an agent, and map them up. In real-life learning, child learners do not solely rely on a learning bias, but rather, dynamically utilize all possible cues available to them; the pro-drop/non pro-drop status of the input language is one such cue. For future studies, looking at what other factors may interact with the learning bias to guide child learners’ attentions is an important direction.

Last but not least, this study, in resonance with other studies that document vocabulary development as a better predictor of syntax growth than age does, shows that children’s performances are largely modulated by their vocabulary knowledge, particularly those predicates used in the experiment stimuli. Knowing or not knowing them may impact children’s encoding of the sentences, and this influence is further interacting with other language-specific knowledge, such as word order.

This study is part of a broader research agenda that investigates the Participant-Argument-Matching hypothesis. PAM, by its name, has two important components – P, participants in the events, and A, arguments in the sentences; in other words, it concerns both the linguistic world and the non-linguistic world,
understanding how each of them works for learners (i.e. how learners encode each input) is therefore crucial to understanding how PAM works. The current study, looking into the distinction between a word-based and a sentence-based version of PAM in the context of complex predicates, focuses on the linguistic side of PAM. Another study within this research agenda specifically looks at the non-linguistic part of PAM, asking what counts as an event participant for learners. Only when we understand how learners assign participant status to entities in the world can we be more confident about our matching theory, because not every entity in the world is perceived as an event participant – some of them may just be bystanders. Current results show that prelinguistic infants assign a different participant role status to the same entity in different types of events. What is more, instruments that do not typically correspond to an argument NP may also be perceived as event participants, again posing questions to PAM-style learning theories, because the represented event structure does not always align one-to-one with the argument structure of its most natural linguistic description.
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