The link between lexical semantic features and children's comprehension of English *be*-passives

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Abstract

Children seem to be relatively delayed in their comprehension of the verbal *be*-passive in English, compared to their acquisition of other constructions of object-movement such as *wh*-questions and unaccusatives. Prior work has found that children's performance on passives can be affected by the verb's lexical semantics. Through a meta-analysis of experimental studies assessing English-speaking children's age of acquisition for the verbal passive, we identify a developmental trajectory composed of five classes, where each class has a distinct lexical semantic profile. A Truth-Value Judgment (**TVJ**) Task assessing English children's comprehension of verbal passives supports this developmental trajectory. Together, the meta-analysis and TVJ study underscore the importance of lexical semantics for understanding the development of the English verbal passive.

keywords: passives, lexical semantics, meta-analysis, Truth-Value Judgment Task, English

1 Introduction

English-speaking children seem to be relatively delayed in their understanding of long verbal *be*-passives (i.e. passives containing a *by*-phrase like (1)-(2)), compared to other constructions of object-movement (e.g. *wh*-questions, unaccusatives). For instance, children over age seven fail to demonstrate understanding of certain verbs in this passive form (Bever, 1970; de Villiers & de Villiers, 1973; Horgan, 1978; Maratsos, Fox, Becker, & Chalkley, 1985, a.o).

(1) Matthew was hugged by Diana.

(2) Matthew was loved by Diana.

Several studies have noted that English children's (un-)successful performance is impacted by the lexical semantics of the verb (Maratsos et al., 1985; Messenger, Branigan, McLean, & Sorace, 2012; Liter, Huelskamp, Weerakoon, & Munn, 2015; Nguyen, 2015). For example, Maratsos et al. (1985) observed that younger children perform better on passives with ACTIONAL (i.e. observable) verbs like *hug* (1) compared to non-ACTIONAL verbs like *love* (2). We will refer to this lexical-feature-based difference in children's performance on passives as a *lexical asymmetry* in children's development of the English verbal passive. Our aim here is to better understand the link between lexical semantic features and the acquisition of the verbal passive in English, focusing on the observed lexical asymmetry.

Current theories of the acquisition of the English verbal passive often appeal to the +/-ACTIONAL distinction (i.e. the sometimes-called "Maratsos Effect") (Gehrke & Grillo, 2009; Grillo, 2008; Liter et al., 2015; Nguyen, 2015; Snyder & Hyams, 2015), but typically don't go beyond this lexical feature. We first review lexical semantic features previously proposed in the experimental literature, and conduct a meta-analysis of experimental studies investigating the age of acquisition for the English verbal passive. We then describe a Truth-Value Judgment (**TVJ**) Task assessing English children's comprehension of passives for different verbs. Our meta-analysis reveals a striking correlation between the lexical semantic profile of verbs, encompassing seven different lexical semantic features, and their observed age of acquisition in the verbal passive form. This correlation

is supported by our TVJ behavioral study with four-year-old children. We discuss the implications of our results for development of the verbal passive in English and also other languages.

2 Lexical semantic features

Several experimental studies (Maratsos et al., 1985; Pinker, Lebeaux, & Frost, 1987; Messenger et al., 2012; Liter et al., 2015; Nguyen, 2015) have collectively described seven potentially relevant lexical semantic features that can affect children's performance (Table 1): ACTIONAL, STATIVE, VOLITIONAL, AFFECTED, and the thematic-role relations object-experiencer (OBJ-EXP), subject-experiencer (SUBJ-EXP), and agent-patient (AGT-PAT). We note that these tend to be descriptive features proposed by experimenters to explain specific experimental results rather than theoretically-motivated features that were intended to be mutually exclusive. So, there has not yet been a formal account of how well these descriptive features capture the lexical asymmetry observed in children's development of the long verbal *be*-passive. Moreover, it's not clear whether (or how much) these features overlap semantically. Here, we will treat these features as independent from each other, as there is no theoretical account yet that synthesizes them any other way. We also note that the "signal" of these lexical semantic features is taken from the previous literature, and may be morphosyntactic (e.g., a context the verb can appear in) rather than semantic.

Table 1: Descriptive lexical semantic features derived from prior experimental studies, including signals of that feature and example verbs with (+) and without (-) that feature.

Studies	**Feature**	**Signal**	**+**	**-**
Maratsos et al. (1985) Nguyen (2015)	ACTIONAL	Observable	*eat*	*scare*
Liter et al. (2015)	STATIVE	Simple present tense in "out of the blue" context	*scare*	*eat*
Liter et al. (2015)	VOLITIONAL	"deliberately *VERB*"	*annoy*	*see*
Pinker et al. (1987)	AFFECTED	X affects Y	*annoy*	*like*
Messenger et al. (2012)	OBJ-EXP	-ACTIONAL where object is Experiencer	*frighten*	*chase*
Messenger et al. (2012)	SUBJ-EXP	-ACTIONAL where subject is Experiencer	*like*	*annoy*
Messenger et al. (2012)	AGT-PAT	+ACTIONAL where θ-roles = Agent, Patient	*eat*	*whisper*

The first feature is ACTIONAL, which was defined by Maratsos et al. (1985) as a verb that is *not* a mental, psych, or perception verb. A signal we use to identify an ACTIONAL verb is whether the event described by the verb is observable (Maratsos et al., 1985). So, *eat* would be +ACTIONAL because eating can be directly observed (e.g., *The penguin is eating a fish* – we can observe the penguin eating the fish). In contrast, a psych verb like *love* would be -ACTIONAL because the

internal state caused by loving cannot be directly observed (e.g., *Lisa loves penguins* – we cannot observe Lisa's internal state of pure joy because that psychological state is internal to Lisa).

The next features, STATIVE and VOLITIONAL, were proposed by Liter et al. (2015).[1] Stativity is defined as a verb being acceptable in the simple present tense in an "out of the blue" context (Liter et al., 2015).[2] For example, *Diana loves Matthew* sounds acceptable without any special context (*love*=+STATIVE). This contrasts with *Diana carries Matthew*, which sounds odd out of the blue unless we are narrating an event in real time (*carry*=-STATIVE). Liter et al. (2015) define a verb as VOLITIONAL if it is acceptable when following the adverb *deliberately*. For example, *Matthew deliberately annoyed Diana* sounds acceptable, and describes an event where Matthew made a concerted effort to annoy Diana (*annoy*=+VOLITIONAL). In contrast, *Matthew deliberately saw Diana* sounds somewhat odd in its default interpretation, as it describes an event where Matthew has preternatural control over his visual perception and can choose whether to consciously perceive Diana (*see*=-VOLITIONAL).

The AFFECTED feature was proposed and defined by Pinker et al. (1987), and applies to verbs where the subject affects the object. For example, in *Matthew annoyed Diana*, Diana is affected by Matthew – she is, in fact, annoyed by him (*annoy*=+AFFECTED). This contrasts with *Matthew liked Diana*, where Diana isn't impacted by Matthew liking her, even though Matthew is impacted himself (*like*=-AFFECTED).

The final three features, OBJ-EXP (Object-Experiencer), SUBJ-EXP (Subject-Experiencer), and AGT-PAT (Agent-Patient), were proposed and defined by Messenger et al. (2012), and focus on the thematic status of the object (as either an Experiencer or a Patient).[3] When verbs are -ACTIONAL, they often involve Experiencers. A verb is +OBJ-EXP when the Experiencer is the object (e.g., *Matthew frightens Diana* – Diana is the Experiencer of the fright). A verb is +SUBJ-EXP when the Experiencer is the subject (e.g., *Matthew likes Diana* – Matthew is the Experiencer of the liking). When verbs are +ACTIONAL and the thematic roles are Agent and Patient, the verb is AGT-PAT. For example, *The penguin eats the fish* describes an event where the penguin is the agent and the fish is the patient (*eat*=+AGT-PAT). This contrasts with *whisper* (e.g., *Matthew whispered the secret*), which is +ACTIONAL but does not obviously involve Agent and Patient roles; therefore, it is -AGT-PAT.

We demonstrate the lexical semantic annotation of verbs according to these signals in Table 2. *Find* is an observable action (ACTIONAL=1, STATIVE=0) that is not deliberate (VOLITIONAL=0). In a transitive use, the direct object is unaffected (AFFECTED=0) and a Patient (OBJ-EXP=0, SUBJ-EXP=0, AGT-PAT=1). *Carry* is also an observable action (ACTIONAL=1, STATIVE=0), but can be deliberate (VOLITIONAL=1). In a transitive use, the direct object is affected (AFFECTED=1) and a

[1]The features that Liter et al. (2015) were interested in for their study were specifically EVENTIVE and AGENTIVE. They defined EVENTIVE as a verb being *unacceptable* in the simple present tense in an "out of the blue" context. Here, we use the opposite definition of EVENTIVE for STATIVE. Also, we have renamed AGENTIVE to VOLITIONAL to avoid terminological overlap with the AGT-PAT feature proposed by Messenger et al. (2012).

[2]Stativity can also be defined as a verb being unacceptable in the simple progressive form – for instance, *Diana is loving Matthew* is less acceptable than *Diana is carrying Matthew* (Vendler, 1957). Here, we follow the definition from Liter et al. (2015).

[3]Messenger et al. (2012) used the terms "theme-experiencer" and "experiencer-theme" to refer to OBJ-EXP and SUBJ-EXP respectively.

Patient (OBJ-EXP=0, SUBJ-EXP=0, AGT-PAT=1). *Love* is a stative psych verb (ACTIONAL=0, STATIVE=1) that is not deliberate (VOLITIONAL=0). In a transitive use, the direct object is unaffected (AFFECTED=0) and the subject is the Experiencer (OBJ-EXP=0, SUBJ-EXP=1, AGT-PAT=0).

Table 2: Example identification of lexical semantic features in the verbs *find, carry*, and *love*.

	find	***carry***	***love***
ACTIONAL	*find* ≠ mental, psych, or perception verb. **1**	*carry* ≠ mental, psych, or perception verb. **1**	*love* = psych verb. **0**
STATIVE	*Alex finds Emma. **0**	*Alex carries Emma. **0**	Alex loves Emma. **1**
VOLITIONAL	*Alex deliberately finds Emma. **0**	Alex deliberately carries Emma. **1**	*Alex deliberately loves Emma. **0**
AFFECTED	Alex finds Emma – Emma is unaffected. **0**	Alex carries Emma – Emma is affected. **1**	Alex loves Emma – Emma is unaffected. **0**
OBJ-EXP SUBJ-EXP AGT-PAT	Alex finds Emma. Alex = Agent. Emma = Patient. **0** **0** **1**	Alex carries Emma Alex = Agent. Emma = Patient. **0** **0** **1**	Alex loves Emma Alex = Experiencer. Alex = Subject. **0** **1** **0**

3 Experimental meta-analysis

We synthesized the results of 12 experimental studies that have reported performance on English-speaking children's performance on long verbal *be*-passives across multiple verbs. Our synthesis summarizes (i) the verbs used as stimuli (Table 3), and (ii) children's performance on long verbal *be*-passives for those verbs at different ages (Table 4).[4] This provided the empirical data about the "age of acquisition" (**AoA**) of the passive for each verb. We determined a verb's AoA by assessing the age when children begin performing significantly above chance in any of the studies. For the studies that only reported performance on groups of verbs, an AoA was assigned for each verb that belonged in a group. An AoA could not be determined for a verb if there were no studies in which (i) that verb was tested, and (ii) children showed successful performance on that verb. Of

[4]These studies either reported successful performance on these verbs in the active or did not report any difficulty in comprehending the meanings of these verbs. We take this to mean that unsuccessful performance in these studies results from children's difficulty with these verbs in the verbal passive rather than difficulty with the task or the meanings of the verbs themselves.

the 50 unique verbs tested in these 12 studies, 30 had an AoA by this definition, as shown in Table 4.[5] [6] We subsequently annotated them for their lexical semantic features according to the signals defined in Table 1.

Table 3: Studies, methodology, and verbs used in the experimental meta-analysis.

Studies	**Methodology**	**Verbs tested**
de Villiers and de Villiers (1973)	Act-Out	kiss, push, hit, bite, bump, touch
Maratsos and Abramovitch (1975)	Act-Out	kick, kiss, push, hit, bite, bump, tickle, touch
Maratsos et al. (1985)	Picture-Selection	hold, kick, kiss, push, shake, wash, find, forget, hate, like, love, remember, hear, know, miss, see, smell, watch
Gordon and Chafetz (1990)	Truth-Value Judgment	carry, drop, eat, hold, hug, kick, kiss, shake, wash, forget, hate, like, remember, believe, hear, know, see, watch
Fox and Grodzinsky (1998)	Truth-Value Judgment	chase, hear, see, touch
Hirsch and Wexler (2006)	Picture-Selection	push, kiss, kick, hold, remember, love, hate, see
O'Brien, Grolla, and Lillo-Martin (2006)	Truth-Value Judgment	hug, chase, like, see
Crain, Thornton, and Murasugi (2009)	Elicitation	eat, kiss, push, hit, bite, crash, kill, knock, lick, pick up, punch, scratch, shoot
Messenger et al. (2012)	Picture-Selection	carry, hit, frighten, pat, pull, scare, shock, squash, surprise, upset, hate, love, remember, annoy, bite, hear, ignore, see
Orfitelli (2012)	Picture-Selection	carry, kick, kiss, push, love, remember, hear, see
Nguyen (2015)	Truth-Value Judgment	hug, chase, like, see
Liter et al. (2015)	Truth-Value Judgment	wash, find, fix, forget, paint, spot, hate, love, know

3.1 The lexical semantic profile hypothesis

When verbs were sorted based on observed AoA (i.e., the age of significantly above-chance performance from the meta-analysis), we found that there was a striking relationship between the

[5] Overlap in ages (e.g., 3-4 years old) was a consequence of studies collapsing across multiple age groups.

[6] There were no studies that reported conflicting results for these 30 AoAs.

Table 4: Age of Acquisition (AoA) of verbs from the experimental meta-analysis, representing an AoA by 3 years old (3yr), between 3 and 4 years old (3-4yr), between 4 and 5 years old (4-5yr), and 5 years old (5yr).

AoA	**Verbs**
3yr	carry, drop, eat, hold, hug, kick, kiss, push, shake, wash
3-4yr	annoy, chase, frighten, hit, pat, pull, scare, shock, squash, surprise, upset
4-5yr	find, fix, forget, paint, spot
5yr	hate, like, love, remember

lexical semantic profile of a verb and that verb's observed AoA (see Table 5). In particular, we observed 5 lexical semantic profiles for the 30 verbs. Profile 1 verbs like *carry*, *chase*, and *fix* are +ACTIONAL, +VOLITIONAL, +AFFECTED, and +AGT-PAT. Profile 2 verbs like *annoy* differ from Profile 1 verbs by being +STATIVE (instead of +ACTIONAL) and +OBJ-EXP (instead of +AGT-PAT). Profile 3 verbs like *find* are like Profile 1 verbs in being +ACTIONAL and +AGT-PAT, but differ in being -VOLITIONAL and -AFFECTED. Profile 4 verbs like *forget* are like Profile 3 verbs in being -STATIVE, -VOLITIONAL, and -AFFECTED, but differ in also being -ACTIONAL and +SUBJ-EXP. Profile 5 verbs like *hate* are like Profile 4 verbs in being +SUBJ-EXP, but are additionally +STATIVE.

Table 5: Lexical semantic profiles comprised of the seven lexical semantic features for example verbs with different experimentally observed ages of acquisition (AoA).

	AoA						
	3yrs	**3-4yrs**		**4-5yrs**			**5yrs**
	carry	chase	annoy	fix	find	forget	hate
Profile	**1**	**1**	**2**	**1**	**3**	**4**	**5**
ACTIONAL	1	1	0	1	1	0	0
STATIVE	0	0	1	0	0	0	1
VOLITIONAL	1	1	1	1	0	0	0
AFFECTED	1	1	1	1	0	0	0
OBJ-EXP	0	0	1	0	0	0	0
SUBJ-EXP	0	0	0	0	0	1	1
AGT-PAT	1	1	0	1	1	0	0

Taken together, along with the results for all 30 verbs shown in Table 6, these profiles suggest a natural developmental trajectory for the lexical semantic cues that influence children's ability to interpret long verbal passives. The predicted developmental trajectory is shown in Table 7.

We can interpret these lexical profiles as corresponding to five classes of verbs and the develop-

Table 6: Observed age of acquisition (AoA) for the 30 verbs with an AoA available from the meta-analysis, along with their lexical semantic profile (Profile).

AoA	Verb	Profile	AoA	Verb	Profile
3	carry	1	3-4	annoy	2
3	drop	1	3-4	frighten	2
3	eat	1	3-4	scare	2
3	hold	1	3-4	shock	2
3	hug	1	3-4	surprise	2
3	kick	1	3-4	upset	2
3	kiss	1	4-5	fix	1
3	push	1	4-5	paint	1
3	shake	1	4-5	find	3
3	wash	1	4-5	forget	4
3-4	chase	1	4-5	spot	4
3-4	hit	1	5	hate	5
3-4	pat	1	5	like	5
3-4	pull	1	5	love	5
3-4	squash	1	5	remember	5

Table 7: AoA predictions (Predicted AoA) for example verbs, based on their lexical semantic profiles (Profile).

Profile	Example verbs	Predicted AoA
1	bump, crash, fix, chase, hug	3yrs
2	flatter, hurt	3-4yrs
3	search, discover	4-5yrs
4	spot, notice, overhear	4-5yrs
5	believe, miss, know, remember	5yrs

mental trajectory that we see involves children comprehending successively larger subsets of these five classes (such that three-year-olds understand the first profile and five-year-olds understand all five). A LEXICAL SEMANTIC PROFILE HYPOTHESIS would predict that the discrepancies between the lexical semantic profiles for some verbs and the observed AoA (e.g., Profile 1 verb *fix* with an observed AoA of 4-5yrs) are due to vagaries of the age of the children tested experimentally for those verbs. For example, if *fix* were tested with children age 3, this hypothesis would predict above-chance performance on *fix*'s long verbal *be*-passive. This is one of the stimuli we explicitly test in the TVJ task with younger English children, described in more detail in section 4.

3.2 Limitations of the meta-analysis

The current meta-analysis leaves open several questions. First, while some experimental studies tested three- and five-year-old children as their own age groups, the age overlap in other studies means that four-year-old children were often grouped in with these other ages. Because of this, we do not know exactly how four-year-olds will perform; four-year-olds could pattern with either the three- or five-year-olds or have a distinct performance pattern with respect to these lexical semantic profiles. Second, only one study in our meta-analysis (Messenger et al., 2012) has tested +OBJ-EXP verbs in young children and found that they could successfully interpret these verb types in the long verbal *be*-passive. However, this study was a picture-selection task where pictorial portrayals of stative verbs like *annoy* may have yielded accidental eventive interpretations – so, these accidental eventive interpretations could have led to young children's successful passive interpretations. Because of this possibility, it's unclear if the age of acquisition of the long verbal *be*-passive for Profile 2 verbs like *annoy* is in fact by four years old. Third, Profile 1 verbs (e.g. *fix*) have multiple observed AoAs (e.g., 3, 3-4, and 4-5) but are predicted to be acquired earlier if tested with younger children. Fourth, the meta-analysis combines the results from different groups of children across multiple age ranges using different experimental stimuli and methods (see Table 3 for the different methods). Our lexical semantic profile hypothesis would be strengthened if the same group of children performed as this hypothesis predicts across a variety of verbs with different lexical semantic profiles. We address all of these limitations in the next section with a behavioral assessment using a TVJ task.

4 Truth-Value Judgment Task

We aim to assess if four-year-old children perform as the lexical profile hypothesis predicts when interpreting the long verbal *be*-passive. More specifically, this hypothesis predicts that if children are acquiring the passive form of verbs based on specific lexical profiles, then four-year-olds should successfully comprehend particular verbs with certain lexical profiles earlier than verbs with different lexical profiles. For instance, we would expect four-year-olds to successfully comprehend the passive of Profile 1 verbs like *fix*, and possibly Profile 2, 3, and 4 verbs like *surprise*, *find*, and *forget*. We would expect them not to comprehend the passive of Profile 5 verbs like *love*.

4.1 Subjects

We tested 23 children (3;11-5;01, mean age=4;07) recruited from *[removed for blind review]*. To be included in the data analysis, the child had to correctly answer at least four out of the five active control items (i.e., scoring at least 80% correct), and not exhibit a bias towards a particular answer (i.e., giving the same answer to 90% or more of the test items). Given this inclusion criterion, four children were excluded from the final data analysis. We report results on the data collected from the remaining 19 children, who happened to have the same age range and mean age as the larger group (3;11-5;01, mean age=4;07).

If multiple testing visits were available to a child, that child received a training session (as

described in the next section) prior to the testing session; this training session familiarized her with the task methodology. Otherwise, the child was given verbal instructions for the procedure before proceeding to the test items. 11 of the 19 children who passed the control criterion received a training session.[7]

As adult controls, ten undergraduate students were recruited from *[removed for blind review]*. All participants were native speakers of US English.

4.2 Procedure

A modified version of the Truth-Value Judgment (TVJ) Task (Crain & McKee, 1985; Crain & Thornton, 1998, 2000) was used to investigate the predictions of the lexical semantic profile hypothesis. The TVJ task was carried out by a single experimenter using a laptop computer. Stories were narrated by the experimenter using animated clipart displayed in Microsoft PowerPoint. Participants were told that a puppet would also watch the stories with them and, at the end of each story, describe something that had happened in the story. Participants were then asked to determine whether the puppet's statement was "right" or "silly". The procedure was the same for the training session, but corrective feedback was provided after every item.

For each participant, follow-up justifications were elicited for the first two to three items in order to ascertain the reason for providing "right" or "silly" responses. If participants seemed willing, follow-up justifications were elicited for the rest of the experimental items. Positive feedback was given to participants after every response in order to avoid accidental cues to incorrect answers. All subjects were tested individually.

4.3 Materials

Ten verbs were chosen for testing, two from each of the five lexical profiles identified in the meta-analysis (see Table 8); the stories used in this experiment were created from these 10 verbs (see Appendix A).

Wash (Profile 1) and *love* (Profile 5) were chosen because they are frequently attested to be successfully understood in the long verbal *be*-passive by both younger and older children (Gordon & Chafetz, 1990; Hirsch & Wexler, 2006; Liter et al., 2015; Orfitelli, 2012). *Fix* (Profile 1) was chosen because the lexical semantic profile hypothesis predicts an earlier AoA than the age found by Liter et al. (2015). In particular, Profile 1 verbs are predicted to have an AoA by three, so four-year-olds are predicted to understand *fix* in the long verbal *be*-passive. *Surprise* (Profile 2), *frighten* (Profile 2), *find* (Profile 3), *spot* (Profile 4), and *forget* (Profile 4) were chosen because they have only been tested in one study (Messenger et al. (2012) for *surprise* and *frighten*, Liter et al. (2015) for *find*, *spot*, and *forget*); so, it is unclear how the same group of children will perform on all these verbs. *Discover* (Profile 3) and *believe* (Profile 5) have never been tested before in children.

For each of the 10 verbs, three stories were created: two passive stories, and one active story for control. This yielded 30 stories total. Within each verb, the stories were similar to each other,

[7] We note that there was no statistical difference between children who received training and those who did not.

Table 8: Lexical profiles of the 10 verbs tested and the two lists that these verbs were split into, along with their predicted age of acquisition (Predicted AoA), according to the lexical semantic profile hypothesis.

	List A:	*wash*	*surprise*	*discover*	*spot*	*love*
	List B:	*fix*	*frighten*	*find*	*forget*	*believe*
Profile		**1**	**2**	**3**	**4**	**5**
ACTIONAL		1	0	1	0	0
STATIVE		0	1	0	0	1
VOLITIONAL		1	1	0	0	0
AFFECTED		1	1	0	0	0
OBJ-EXP		0	1	0	0	0
SUBJ-EXP		0	0	0	1	1
AGT-PAT		1	0	1	0	0
Predicted AoA		**3yr**	**3-4yr**	**4-5yr**	**4-5yr**	**5yr**

but differed depending on whether participants were told a passive sentence or an active sentence that either matched or didn't match the story as the test utterance. Test sentences were presented to participants through pre-recorded audio clips spoken by a male native speaker of English. See Appendix A for the 30 stories used and *[url to be inserted here]* for the accompanying Powerpoint presentations.

Sample stories are shown below for the verbs *frighten* (passive test sentence, mismatch for story) and *love* (passive test sentence, match for story)[8] :

Sample Story 1 - *frighten*, Profile 2, Mismatch
Narrator: Owen and Jackie are at a costume party. Ladybugs frighten Owen but Jackie loves ladybugs and that's why she's dressed as one for the party.
Jackie: Owen, do you see my ladybug costume? Do I frighten you?
Owen [*frowning*]: Yes, Jackie, you frighten me. You know that I don't like ladybugs!
Test Sentence: Jackie was frightened by Owen. (False)

[8] We note that the test stories did not include plausible dissent in order to keep them uniform to each other and simple enough to allow for multiple test stories within a single session. This may have made all the stories less felicitous, and so potentially caused four-year-olds not to correctly comprehend the passive for a particular verb when they might have comprehended it in a setup with plausible dissent. However, because all stories were alike in this regard, we expect this to have a global effect, potentially lowering correct comprehension rates across all profiles. So, the qualitative pattern we report below likely would remain the same, though perhaps the profile on the borderline (Profile 4) might have moved into being accepted by four-year-olds in a more felicitous setup. We leave this for future work.

Sample Story 2 - *love*, Profile 5, Match
Narrator: Jake and Isabelle are neighbors. They play with each other every day.
Isabelle: Jake, I don't love you because I'm jealous of your new clothes.
Jake: But I love you because you're my only friend, Isabelle!
Test Sentence: Isabelle was loved by Jake. (True)

The stories were also constructed such that any reliance on linear word order for interpretation would always lead to an incorrect response. For example, in the Sample Story 2 above, a child could interpret the passive test sentence *Isabelle was loved by Jake* as *Isabelle loved Jake* by relying on only the linear word order (either due to confusion or lack of structural knowledge of the passive); the child would then provide an incorrect response to the test sentence (False in Sample Story 2). Consistently relying on a linear-word-order strategy like that would result in the child systematically providing incorrect responses. Furthermore, for the verbs that fell under Profiles 2 and 5 and so were +STATIVE, we wanted to avoid accidental eventive interpretations and so kept movement to a minimum within the test materials; participants thus had to rely on the dialogue of the stories in order to fully comprehend the contexts.

The 10 verbs and their corresponding stories were split into two lists as shown in Table 8. Adult participants were presented with both lists and thus saw all 30 stories. Child participants were presented with one of the two lists. So, each child participant was tested on a total of 15 stories: three stories (two passives and one active) for each of the five verbs in the list. Children who were tested in a single session, and so did not receive a training session, were presented with List A verbs; children who did receive a training session were presented with List B verbs. The materials for the training session were drawn from the active control items from List A since these children would always be presented with List B verbs during the experimental session.

4.4 Results and discussion

The performance of child participants who received a training session did not statistically differ from those who did not receive a training session ($t(11.24) = -0.01, p = 0.9$, independent-samples t-test) and thus the data will be collapsed across the two groups for further analysis. Figures 1 and 2 show the percentage of correct responses by adults and four-year-old children, respectively. Table 9 shows the results of participants' comprehension as compared to chance performance (single-sample *t*-tests) for each verb profile for the adults and the four-year-olds.

For the adult participants, all 10 subjects performed effectively at ceiling and were significantly above chance across all five lexical profiles. We thus take this as evidence that our test materials elicited the correct answers from adults. Moreover, we interpret this to mean that our baseline for adult-like knowledge is successful and, more importantly, that there is equally good performance across all lexical profiles.

Turning to the four-year-olds, children were effectively at ceiling for the active control items; we interpret this to mean that children were paying attention to the experiment and knew the target verbs well enough to comprehend them in the active form. For the passive items, four-year-olds performed significantly above chance for Profiles 1, 2, and 3, but were no different from chance for Profiles 4 and 5 (Table 9).

Figure 1: Percentage of correct responses by verb profile for adult controls. (Error bars indicate standard error.)

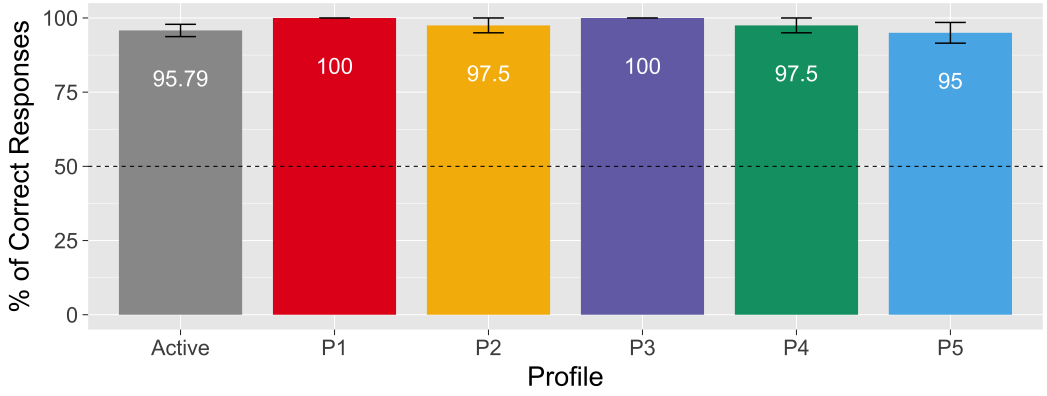

Figure 2: Percentage of correct responses by verb profile for four-year-olds. (Error bars indicate standard error.)

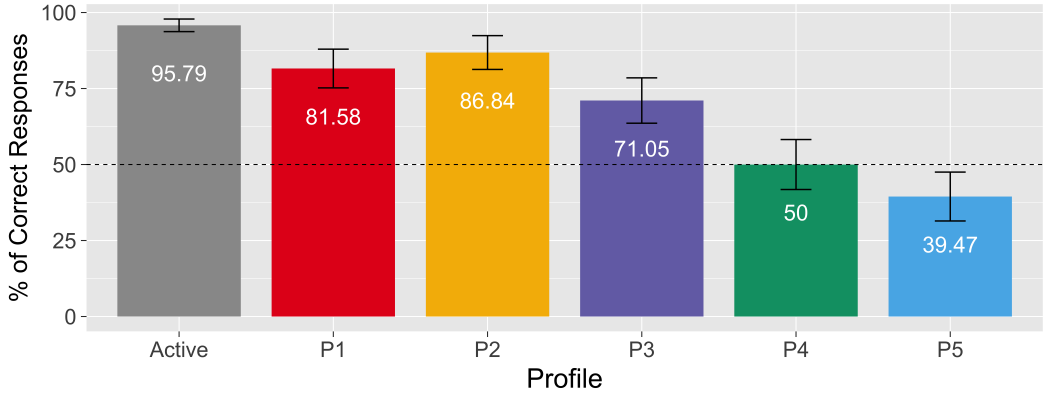

Table 9: Accuracy rates for four-year-olds (left) and adults (right) by verb profile, compared to chance (50%).

Adults					**4-year-olds**				
Profile	**Percentage Correct**	***t***	***df***	***p***	**Profile**	**Percentage Correct**	***t***	***df***	***p***
1	100.00%	inf	9	<.001	1	81.58%	4.610	18	<.001
2	97.50%	19	9	<.001	2	86.84%	7.098	18	<.001
3	100.00%	inf	9	<.001	3	71.05%	3.023	18	0.003
4	97.50%	19	9	<.001	4	50.00%	0.000	18	0.500
5	95.00%	13.5	9	<.001	5	39.47%	-1.287	18	0.107

We conducted three additional analyses, based on our meta-analysis. First, our meta-analysis found that Profile 1 had an AoA of three years old while Profile 5 had an AoA of five years old; so,

we conducted a planned comparison between Profiles 1 and 5 on our sample of four-year-olds. The lexical semantic profile hypothesis would predict that four-year-olds should perform differently on verbs from these two profiles. We found that this was indeed true: four-year-olds performed better on Profile 1 than Profile 5 (W= 107, P= 0.0013, Wilcoxon Signed-Rank Test). We interpret this to mean that four-year-olds' performance do differ between these two profiles such that children were more successful on Profile 1 verbs than Profile 5 verbs. Furthermore, children's unsuccessful performance on Profile 5 suggests that Profile 5 verbs have an AoA later than four years of age.

Second, we were interested in how children would perform on Profile 2 verbs when the material controlled for accidental eventive readings of the verbs *surprise* and *frighten*. In particular, was the AoA for Profile 2 verbs four years old? We compared the four-year-olds' performance on Profile 2 to Profile 1 and Profile 5. We found that children performed no differently on Profile 2 than on Profile 1 (W= -7, P= Not Significant, Wilcoxon Signed-Rank Test); moreover, four-year-olds were significantly better on Profile 2 than on Profile 5 (W= 91, P= 0.0008, Wilcoxon Signed-Rank Test). We take this to mean that four-year-olds were equally successful with passives of Profile 1 and Profile 2 verbs and that the AoA for Profile 2 is, at the latest, four years old.

Third, it was unclear from our meta-analysis if four-year-olds had a comprehension pattern similar to either three- or five-year-olds, or instead had their own separate comprehension pattern. Recall from Table 6 that three-year-olds have been observed to comprehend Profiles 1 and 2, while five-year-olds have been observed to comprehend Profiles 1, 2, 3, 4, and 5. To assess whether four-year-old children exhibit a pattern different from that of both three-year-olds and five-year-olds, we compared the three profiles on which these four-year-olds performed significantly above chance (Profiles 1-3) to the two profiles on which they did not (Profiles 4-5). We found that four-year-olds' performance was asymmetric: they were reliably better on verbs from Profiles 1-3 than on verbs from Profiles 4-5 (W= 161, P= 0.0005, Wilcoxon Signed-Rank Test). This suggests that four-year-old children are exhibiting a pattern that is distinct from the patterns observed previously for three- and five-year-olds. In particular, four-year-olds comprehend Profiles 1, 2, and 3, while three-year-olds haven't been observed to comprehend Profile 3 and five-year-olds have been observed to additionally comprehend Profiles 4 and 5.

Taken together, our results support the lexical semantic profile hypothesis for English: four-year-old children can successfully understand the long verbal *be*-passive for verbs in "earlier" profiles (Profiles 1, 2, and 3) but not the verbs in "later" profiles (Profile 4 and 5). In addition, four-year-olds seem to pattern differently than both the three- and five-year-olds in the meta-analysis, comprehending one more profile (Profile 3) than the three-year-olds, and two fewer than the five-year-olds (Profiles 4 and 5). One possible explanation for why the four-year-olds were not successful on Profile 4 verbs, as suggested by our meta-analysis, could be that performance was driven by the five-year-olds in those studies. Another possibility, as discussed in footnote 8, is that the lack of plausible dissent artificially depressed four-year-old performance on Profile 4 verbs, making the performance appear at chance when it in fact wouldn't be in a more felicitous setup. We note that if four-year-olds do in fact comprehend Profile 4 verbs correctly in the passive, our qualitative results do not change. The four-year-olds would still pattern differently from the three- and five-year-olds, and the lexical semantic hypothesis is still supported as children of different ages seem to be able to comprehend progressively more lexical semantic profiles in the passive. More generally, the

distinction in the lexical asymmetry patterns across the three different age groups supports our hypothesis that English-speaking children's performance on long verbal *be*-passive is linked to the lexical semantic profile of the verbs.

Our results further suggest that four-year-old English children have structural knowledge of the passive and are not strictly relying on linear word order. More specifically, if they were relying on linear word order, they would interpret passive sentences as active sentences (i.e., interpreting *Jake was loved by Isabelle* as *Jake loved Isabelle*). In our TVJ task, they would then perform significantly below chance (e.g., giving the opposite response every time). Instead, four-year-olds performed above chance for verbs from Profiles 1-3, and no different from chance for verbs from Profiles 4 and 5. So, our results support four-year-olds having structural knowledge of the passive form.

With respect to prior studies, our results align with Messenger et al. (2012), who found comparable performance between AGT-PAT verbs (Profiles 1 & 3) and OBJ-EXP verbs (Profile 2) in three- and four-year-old children. Our results also align with those of Maratsos et al. (1985), who found that four-year-olds fail to comprehend non-ACTIONAL verbs like *love* and *remember*, both of which are Profile 5 verbs. We too found that four-year-olds did not understand the long verbal *be*-passive of *love*. However, we did find success with non-ACTIONAL verbs from Profile 2: *surprise* and *frighten*. Taken together, the lexical semantic profile hypothesis can replace prior explanations meant to account for the results of Messenger et al. (2012) and Maratsos et al. (1985).

5 Closing remarks

Here we have provided a synthesis of prior experimental work on the development of the long verbal *be*-passive in English. This meta-analysis revealed a correlation between the lexical semantic profile of a verb and its age of acquisition for the long verbal *be*-passive; from this, we posited a lexical semantic profile hypothesis, where the lexical semantic features of a verb collectively predict its age of acquisition. A Truth-Value Judgment task with four-year-olds supported this hypothesis, with the children successfully understanding the long verbal *be*-passive of verbs with profiles predicted to have an earlier age of acquisition. While we focused on English, it is possible that the lexical semantic hypothesis may also apply cross-linguistically. That is, even for languages where children seem to comprehend that passive quite early (e.g., Sesotho: Demuth, Moloi, & Machobane, 2010), it could be that they still comprehend verbs from certain lexical semantic profiles earlier than verbs from other lexical semantic profiles. Future experimental work may be able to assess if there is in fact a lexical asymmetry even in those languages where children comprehend the passive much earlier than in English.

From a knowledge representation standpoint, we again note that the seven lexical semantic features included in the lexical semantic profiles investigated here were proposed as a description of the relevant verb properties. However, it's unclear if they are truly separate or if instead there is overlap that would be better represented with a smaller number of features (e.g., ACTIONAL and AGT-PAT might be better represented by a single feature, because they had the same value for all five profiles we identified). Future theoretical work can investigate other lexical semantic feature representations that are also compatible with the empirical data collected so far. More generally,

our findings underscore the role of lexical semantic features – and in fact, collections of these features into profiles – that correspond very well to children's observed age of acquisition of the long verbal *be*-passive in English.

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A Materials used in the TVJ Task

BELIEVE - Active
Uncle is babysitting his nephew, Luke.
Luke runs into the living room and says to Uncle.
Luke: I saw a unicorn today. It was really big and shiny. Do you believe me?
Uncle: Of course I believe you. I saw one too! Do you believe me?
Luke: No! I was the only one that saw the unicorn.

BELIEVE - Passive
Auntie is babysitting her nephew, Wyatt.
Auntie: Wyatt, I ate all of my vegetables today. Do you believe me?
Wyatt: Of course, I believe you! You love vegetables. I also ate all of my vegetables today.
Auntie: But I didn't pack any vegetables in your lunch today! I don't believe you.

BELIEVE - Passive
Joel and Jane are best friends.
Jane: My parents are taking me to Disney World for my birthday. Do you believe me?
Joel: I definitely believe you. Your parents are so nice. My parents forgot about my birthday.
Jane: I don't believe you. I heard that your parents are throwing you a birthday party this year!

DISCOVER - Active
This is a story about a lion and Edward the explorer.

The lion is roaming the safari. Then, Edward the explorer arrives.
Edward: What's this? Look, I've discovered a lion in the safari.

DISCOVER - Passive
The thief is hiding behind a tree with his stolen diamond ring.
Thief: Ha! I'm safe behind this tree with my ring. No one will be able to discover me in this park. I'll take this time to sleep.
Maria is walking around the park.
Maria: Hmm... Is anyone here? Who's this? I've discovered the diamond thief!

DISCOVER - Passive
This is a story about Michael and a pirate. The pirate is hiding away on an island with her treasure chest.
Pirate: Arg! I'm safe on this island with my treasure. I do not see anyone so no one will discover me and my treasure!
Michael is sailing the ocean when he came upon an island.
Michael: Ah! A deserted island. Is anyone here? Oh look, I've discovered a pirate!

FIND - Active
The thief is hiding behind the tree with the diamond ring.
Thief: I will hide behind this tree. No one is around to find me. I'll sleep for a little bit.
Lincoln is walking around the park.
Lincoln: I wonder if there is anything behind this tree. Look, I found someone!
Thief: Aak! You found me!

FIND - Passive
This is a story about Jason and the farmer. The farmer is looking for his tools.
Farmer: hmmm, I wondering if my tools are behind this big doghouse! I can't see anything so no one will be able to find me behind here.
Jason was walking around the backyard.
Jason: hmmm.... That's a really big dog house. I'll just walk around it to get to the other side of the backyard. Oh look, it's the farmer! I found the farmer.

FIND - Passive
This is a story about June and Lincoln. June is looking for her diamond ring.
June: I wonder where this ring could be. I'll look behind this big bench here. It's hard for people to see me when I'm behind this bench. I'm sure no one will find me here while I'm looking for this ring!
Lincoln is enjoying a lovely day at the park.
Lincoln: What a great walk! I'll sit down on this bench and rest a bit. Oh, who's this? Looks like I found my friend, June!

FIX - Active
The Grey Robot and the Green Robot are working in the office today. The Grey Robot and the Green Robot accidentally bumped into the cabinets and some of their screws fell onto the floor.
Grey Robot : I only have a pen. Pens won't fix this problem.
Green Robot : That's okay, I have a very good screwdriver. I will fix you, Grey Robot!

FIX - Passive
The Round Robot and the Square Robot are hanging out in the laboratory one day.
Suddenly, both their arms fell off their body!
Round Robot: I only have a paintbrush. Paintbrushes can't fix Robots.
Square Robot: Don't worry, I have a wrench. I can fix your arm!

FIX - Passive
The Blue Robot and the Yellow Robot are together in the laboratory mixing chemicals.
There was a big explosion. Looks there are wires everywhere.
Yellow Robot: I only have scissors. Scissors will not fix our wires.
Blue Robot: I have superglue! I will fix you!

FORGET - Active
Mommy and Audrey are at the mall. Audrey is staring at the toys when Mommy walks off.
Audrey: Mommy! Where are you going? Did you forget me?
Mommy: Oh gosh, it's true. I'm sorry. I forgot you in the store.

FORGET - Passive
Lucas and Mary are at the playground. Mary is playing by herself.
Lucas: Hey, I did not forget you! We were playing together last week!
Mary: No, I forgot who I was playing with last week.

FORGET - Passive
Chase and Chloe are at school. Chase is playing by himself.
Chloe: Hey, I did not forget you! I played at your house last week.
Chase: You did? I forgot who was at my house last week.

FRIGHTEN - Active
Cole and Aurora are going to a party. Pirates frighten Aurora but Cole loves pirates.
Cole: Your costume is awesome, Aurora. Look, I'm dressed as a pirates. Do I frighten you?
Aurora: Yes, you frighten me! Pirates don't look very nice.

FRIGHTEN - Passive
Andrew and Caroline are at a Halloween party. Mummies frighten Caroline but Andrew loves mummies.
Andrew: Look, Caroline, I'm dressed as a mummy. Do I frighten you?

Caroline: Yes, you frighten me! I can barely see you coming for me!

FRIGHTEN - Passive
Owen and Jackie are at a costume party. Ladybugs frighten Owen but Jackie loves ladybugs.
Jackie: Owen, I love your witch costume! Do you see my ladybug costume? Does it frighten you?
Owen: Yes, Jackie, you frighten me. You know that I don't like ladybugs!

LOVE - Active
The boy is playing around with his cat. The boy loves it when the cat plays with him.
Boy: oh my goodness, you are so cute, kitty. I love you! Do you love me?
Cat: *hisses* no, I do not love you!

LOVE - Passive
Uncle is babysitting his nephew, Alexander. Uncle and Alexander are talking in the living room.
Uncle: You are the cutest kid I know. I love you very much. Do you love your uncle, Alexander?
Alexander: No! I only love mommy and daddy.

LOVE - Passive
Jake and Isabelle are neighbors. They play with each other every day.
Isabelle: Jake, I don't love you because I'm jealous of your new clothes.
Jake: But I love you because you're my only friend, Isabelle!

SURPRISE - Active
Cole and Amelia are best friends. It's Amelia's birthday and Cole wants to do something for her.
Cole: Amelia, I want to surprise you! Happy birthday!
Amelia: Yay! I was not expecting this at all. I am so happy!

SURPRISE - Passive
Clara and Owen are at a baseball field. Owen bought something very special for Clara.
Owen: Look, Clara! I want to surprise you. New baseball mitts!
Clara: Thanks, Owen! You really surprised me! I have nothing to surprise you with today.

SURPRISE - Passive
Mommy and Caroline are shopping at the toy store. Mommy bought Caroline something very special.
Mommy: Caroline, I want to surprise you! Look, a new bike!
Caroline: Wow! So cool! But I can't surprise you, Mommy, you have everything!

SPOT - Active
The boy is playing around with his pet monkey. When the boy wasn't looking, the monkey climbed up one of the trees.
Boy: ah, I spot you hiding in the tree, Monkey! You silly monkey.

SPOT - Passive
Auntie is babysitting her niece, Audrey. Audrey goes behind the curtain.
Audrey: I'm hiding from Auntie behind this big curtain. I can't see anything but I bet Auntie will not spot me.
Auntie: Oh, there are little shoes poking out from the bottom of the curtain. I spot you, Audrey!

SPOT - Passive
Uncle is babysitting his niece, Chloe. Chloe goes behind the brooms.
Chloe: I'm hiding from Uncle behind these brooms. I can't see anything but I bet Uncle will not spot me.
Uncle: Oh, there are pigtails poking out from the brooms. I spot you, Chloe!

WASH - Active
Harvey is playing with his dog in the backyard.
Look how dirty they're getting!
Harvey: You're so dirty, dog. I need to wash you before we go back into the house.

WASH - Passive
Ava and Andrew are in the kitchen. Look! Ava is spilling juice everywhere.
Ava: Aww! There's juice on my dress. I have nothing to wash this off with!
Andrew: I have a wet towel. Let me wash you, Ava.

WASH - Passive
Benji and Anna are in the bathroom. Benji and Anna are dirty from playing outside.
Anna: I can't find anything to wash you with, Benji.
Benji: I found a sponge! I don't mind being dirty; I will wash you first, Anna.