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The Language of Mechanical Support in Children: Is It 'Sticking', 'Hanging', or Simply 'On'?

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Abstract

Research has found that children begin to differentiate in the terms they use to encode support. In English, BE on, the Basic Locative Construction (Levinson & Wilkins, 2006; "put on" in dynamic events) tends to encode support-from-below (e.g., cup on table), whereas lexical support verbs (e.g., hang, stick, tape, glue, etc.) tend to encode mechanical support. We see this differentiation in semantic space by six years of age (Johannes et al., 2016). Although this differentiation occurs, we can still use BE on to encode all types of support, just as we can use a variety of lexical verbs (e.g., the picture is on/put on the wall, the picture is hanging on the wall, the picture is stuck to the wall, the picture is taped to the wall), In this study we ask several questions: 1) do four-year-olds use more lexical verbs to describe dynamic events compared to previous studies (Johannes et al., 2016; Landau et al., 2017) that use static stimuli, 2) does visibility of the support mechanism play a role in the lexical support verbs used and 3) do participants show a bias to encode specific aspects of the spatial configuration over another by using one class of verbs more, specifically do they encode the resulting spatial configuration (use Verbs of Putting in a Spatial configuration more; "hang") or the manner of attachment (use Verbs of Attaching more; "stick, tape, clip"). The results suggest that four-year-olds use lexical verbs more than previous studies, suggesting that dynamic events elicit more lexical verbs compared to static stimuli. Further, we found that visibility does impact participants' verbs use, and that participants have a linguistic bias when describing mechanical support events. Our results have implications for children's knowledge of support mechanisms and how children reason about physical support events.

Keywords: language development, support, mechanism, spatial language, semantics

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The Language of Mechanical Support in Children: Is it 'Sticking', 'Hanging', or simply 'On'?

By

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Physical support, in which one object prevents another from falling, is a key concept used in everyday life. Imagine not knowing that a desk will support your coffee mug, your wrist will support your watch, your backpack can be hung on a hook, and sticky notes will adhere to your computer screen. Such knowledge is used frequently in our daily interactions and the foundation of this knowledge has been found early in development. For example, Baillargeon, Li, Ng, and Yuan (2009) found that infants at 2.5 - 3.5 months expect an object in mid-air to fall, but they are not surprised if the object is placed on the side of another object and does not fall, suggesting that infants may understand that support requires contact between one object (the supporter) and another (the thing supported). But by 4.5 months of age, infants are surprised when an object that is placed on the side of another object does not fall, suggesting that the location of contact is now relevant, in addition to simple contact: an object is supported when it is placed on top of another object but not on the side of another object (Needham & Baillargeon, 1993). At around 5 months of age, infants use more complex reasoning about support, such that they will reach for an object 'supported from below' rather than via the side because they may reason that the object supported via the side is attached and cannot be grabbed (Hespos & Baillargeon, 2008). Research also suggests that infants may reason about the forces causing support. Baillargeon et al., (2009) found that infants were not surprised when a box remained stable after being placed on the side of a box that was previously shown to be self-propelled, suggesting that they may have reasoned that the self-propelled object could use its own internal energy to prevent the box from falling.

Given the broad range of configurations portraying support, as well as the importance of 'force' in how infants reason about support, previous studies suggest that the terms typically used to encode support (English 'on' and equivalents in other languages) are best understood as

representing force-dynamic relationship of the support configuration between figure and ground objects (Coventry, Carmichael, & Garrod, 1994; Herskovits, 1986; Landau, 2017; Vandeloise, 2010). For example, support from below (e.g., a cup on a table) involves a solid ground object (table) preventing a figure object (cup) from falling. Encirclement (e.g., watch on a wrist) involves the figure (watch) being prevented from falling by the solid ground object (wrist), and hanging (e.g., coat on a coat tree) involves the figure (coat) being downward orientation and prevented from falling by the ground (coat tree). There are also support types that involve a specific 'mechanism,' such as tape that adheres a picture to a wall or a clip that attaches a sheet of paper to a binder. Further, there are not just variations in the force-dynamic relations, but there is variation in how languages map language to different types of support. For example, English uses 'on' to encode various types of support, whereas uses terms such as 'op' to encode 'stable'/ 'solid' support (e.g., cookie on plate) and 'om' to encode encirclement (e.g., necklace on neck) (Gentner & Bowerman, 2009). Given the broad range of support types and the differences across languages in mapping language to support relations, research has examined how children understand and encode support. Research has found that children are able to map language to support starting at the earliest stages of language development (Lakusta, Brucato, & Landau, 2020).

Recent research has examined children's language development within different domains of support, but questions remain about how young children acquire and use the language encoding mechanical support. Mechanical support can be understood as support that is *not* achieved by a figure object being supported from below (cup on table), but rather through 'mechanical means' such as Embedded Support (e.g., picture on shirt), Support via Adhesion (e.g., sticker on wall), Support via Hanging (hat on hook), and Support via Point Attachment

(e.g., flag on pole) (Landau, Johannes, Skordos, & Papafragou, 2017). Findings suggest that early in language development support from below is the "core" of support representations and is differentiated from mechanical support, suggesting a "division of labor" in how support is represented in language (Landau et al., 2017; Lakusta et al., 2020; Lakusta, Hussein, Wodzinski, & Landau, 2021; see Landau, 2018 for a discussion). Yet, despite this initial differentiation in how children represent mechanical support, there are questions regarding how children map language to support such as lexical expressions (e.g., stuck to, hanging on, taped to). For example, when presented with a picture adhered to a wall via tape, in English one can describe this relation as "the picture is *hanging on* the wall" which encodes the specific spatial configuration of the picture in a specific location on the wall (*it is hanging*). Or, one can describe the relation as "the picture *is taped to* the wall" which encodes the manner of attachment - the mechanism/fastener (tape) - that is used to accomplish the support. Or, one can describe neither the spatial configuration nor the manner of attachment and say, "the picture *is on* the wall". This leads us to ask do young children show biases in how they encode mechanical support configurations? Recent research examining children's language of *static* mechanical support configurations (a picture on wall) suggests that they do. Four-year-olds prefer to encode static configurations with the Basic Locative Construction (e.g., in English, BE *on*; e.g., "the picture *is on* the wall", Landau et al., 2017).

The aim of this paper is to continue exploring this question. It has been shown that biases in language play a significant role in language acquisition as well as non-linguistic cognition. For example, research has found a preference for encoding goals (end points/states; e.g., the girl hopped to the store) over sources (starting points/states; e.g., the girl hopped from the car) (e.g., Lakusta & Landau, 2005; Lakusta & Landau, 2012; Papafragou, 2010) and agents over patients

(Cohen & Oakes, 1993; Dowty, 1991), which has shed light on how children map language to specific components of an action event. In the current study, we examine linguistic biases within mechanical support for dynamic events.

We know from several studies that early in language acquisition children describe motion events (e.g., girl putting the cap on the pen, person walking from x to y) with many different linguistic expressions in their first language (e.g., Allen et al., 2007; Bowerman, 1996; Choi & Bowerman, 1991; Choi, 2006; Hickman & Taranne, 2009). Yet, most of the studies examining the language of mechanical support have focused on static configurations, such as a mug hanging from a stand, a stamp on an envelope, or an apple on a tree (e.g., Gentner & Bowerman, 2009; Landau et al., 2017). Dynamic support events are likely to elicit different verbs compared to static configurations. For example, BE *on* encodes the state of static support (the picture *is on* the wall), whereas light verbs such as 'put' and 'place' encode the motion, require an agent, and encode the resulting state of support (the girl *put* the picture *on* the wall). Given that support can be understood in terms of a force-*dynamic* relation between a figure and a ground (Coventry et al., 1994; Herskovits, 1986; Landau, 2018; Vandeloise, 2010), it is possible that the mechanics involved in the force and relation may be more likely to be encoded in an dynamic event with an agent (a girl using tape to put a picture on the wall) versus a static end-state (picture on wall via tape). Thus, in the current study, we test how children and adults encode mechanical support events, and whether they show a linguistic bias to encode the end-state over the manner of attaching in dynamic events.

The linguistic encoding of support and a "division of labor"

Research suggests that there is a "division of labor" in how children and adults encode support, and this differentiation shows up early in development with there being evidence across

languages. For example, in two studies by Landau and colleagues (Landau et al., 2017; Johannes, Wilson, & Landau, 2016), adults and six- and four-year-old children were presented with static configurations of different types of support relationships (e.g., apple in bowl, cup on plate). They tested several subtypes of support: Gravitational support (support from below, henceforth, SFB), Embedded support (e.g., a tattoo on a hand), Adhesion (e.g., stamp on a paper), Hanging (e.g., coat on a hook), and Point-attachment (e.g., keychain on a backpack). Adults typed their responses to the prompt "Where is the XX with respect to the XXX?", and children were asked "What's the arrow pointing to?" followed by "Where's the XX (the label they gave the figure object)?" The findings showed that English-speaking adults and 6-year-old children used the 'Basic Locative Construction' (Levinson & Wilkins, 2006), BE *on,* more frequently than lexical verbs to encode SFB (Landau et al., 2017; Johannes et al., 2016), whereas they tended to use more lexical verbs (g. attach, connect, stick, hang, pin) to encode mechanical support. Greek children demonstrated the same pattern, whereas English-speaking four-year-old children overgeneralized BE *on* to all subtypes of support in an elicited production task, suggesting a bias to use the Basic Locative Construction to encode mechanical support. However, four-year-olds showed the same pattern as older children and adults in a forced-choice comprehension task, such that when presented with static mechanical support configurations (e.g., post-it note on book) and asked to choose between a lexical verb (e.g., is stuck to) or "is on" to describe the image, they selected the appropriate lexical verb more. This suggests that although young children may have an understanding of some lexical verbs, when there is lexical competition (Johannes et al., 2016), the Basic Locative Construction 'wins' over a lexical verb, at least when being asked to describe *static* configurations of support (e.g., the coat is on the hook vs. the coat is hanging on the hook). In the current study, we test whether this pattern remains when children

are presented with *dynamic* configurations of mechanical support, or whether children may be more likely to use lexical verbs (e.g., stick, hang, tape) to describe dynamic events (compared to static).

A Case Study of Mechanical Support: Hanging via Attachment

In this study, we focus on configurations of mechanical support via attachment that show a figure object hanging from a ground object (e.g., picture on wall via tape, paper on board via clip). These configurations allow us to examine how children acquire the language of mechanical support because they can be described with different types of verbs that encode different aspects of the support configuration (BE *on*, put/place on, hang on/from, stick to, tape to), and these configurations have also been used in previous studies examining support. For example, Bowerman and Pederson (c.f. Gentner and Bowerman, 2009) examine how 50 different languages categorize static spatial configurations based on the terms that were used to describe them, and they propose a continuum of support types:

> (a) "support from below" (e.g., cup on table, man on roof), (b) "clingy attachment" (e.g., bandaid on leg, raindrops on window), (c) "hanging against" (e.g., picture on wall, coat on banister), (d) "point-to-point attachment" (e.g., apple on branch, string on balloon), (e) "encirclement with contact" (e.g., ribbon on candle, ring on finger), and (f) "full containment" (e.g., apple in bowl, rabbit in cage). (p. 469)

Note that except for the "full containment," situation types (b) - (d), all the situation types above relate to some type of attachment and/or hanging, which may involve a specific mechanism (e.g., stickiness of the bandaid, a hook or tape for the picture, a knot for the string on the balloon).

An analysis of English verbs by Levin (1993) discusses hanging and attachment suggesting two distinct verb classes that are relevant for our study (see Table 1): 1) Put Verbs;

e.g., light verbs such as ‘put’ and ‘place’ that do *not* specify a spatial configuration, and Verbs of Putting in a Spatial Configuration; e.g., ‘hang,’ ‘dangle,’ etc., that do specify a specific location within a spatial configuration, and 2) Verbs of Combining and Attaching; e.g., ‘stick,’ ‘attach,’ etc., that do *not* specify a specific fastener, and Tape Verbs; e.g., ‘tape,’ ‘glue,’ ‘clip,’ etc., which do specify a specific fastener. This analysis provides further evidence how different verbs can be used to encode the same configuration (e.g., the girl put the picture on the wall, the girl hung the picture on the wall, the girl stuck the picture on the wall, the girl taped the picture on the wall). ‘Put’ and ‘place’ - the Basic Locative Construction for encoding motion events of support- encode the support configuration in a dynamic event *without* encoding the specific spatial configuration of the figure relative to the ground or the specific mechanism/fastener. In contrast, ‘hang’ encodes the specific spatial location of the figure relative to the ground, but ‘stick’ encodes something about the mechanism (it is sticky) *without* encoding the specific fastener that was used, and ‘tape’ encodes the specific mechanism/fastener (e.g., piece of tape).

Given the variety of descriptions that can be used to encode mechanical support configurations, we examine how children encode support configurations of hanging via attachment. We ask, do four-year-olds prefer the Basic Locative Construction (‘put’/ ‘place’ on) when encoding dynamic events of mechanical support, similar to how they describe static configurations (Landau et al., 2017; Johannes et al., 2016), or do they use more diverse language, including more specific lexical verbs that encode how support is accomplished?

Table 1

Verb Classes relevant for encoding support configurations (based on Levin, 1993)

Verb Class	Verbs[a]
Put Verbs[b]	put, place
Verbs of Putting in a Spatial Configuration	hang, dangle
General Verbs of Attaching	stick, attach, connect
Specific Verbs of Attaching	clip, tape, pin
Other Verbs	use

[a]The verbs listed are examples of each verb class according to Levin (1993), as well as verbs that were used in our pilot study. The examples below do not provide an exhaustive list of all the verbs that Levin includes in each class.

[b]Note that for the 'Put Verbs', put and place are semantically similar to BE *on* - the Basic Locative Construction - for encoding static support configurations in English. The only differences are that 'put' and 'place' encode an event, whereas BE encodes a state.

The current study

Similar to previous research (Johannes et al., 2016; Lakusta et al., 2020), an elicited production task was conducted with four- and six-year-old children, as well as adults (their parents). The current experiment differed from previous studies in that the stimuli used *dynamic* events of a figure object being attached/hung on a ground object. In half of the events, a hand

appeared and attached a piece of paper (from its top) to a ground object (tree/door) via a visible piece of tape, clip, or pin (see Figure 1). In half the events, the mechanism (tape, clip, pin) will be hidden (covered by figure object), to explore how the visibility of a mechanism/fastener may influence the verbs (or lack thereof) that children and adults use to describe the events. Our predictions are listed below and restated in Table 2:

1) Given that four-year-olds overgeneralize the Basic Locative Construction (BE *on*) to static mechanical support configurations in previous studies (Landau et al., 2017), if they continue to show the same pattern with dynamic events of mechanical support, they should use the semantically identical verbs, 'put'/ 'place', and describe the events such as, "she put the paper on the door." However, if dynamic events elicit different linguistic descriptions compared to static configurations (possibly because the mechanism involved in the force dynamics of the support is more likely to be encoded), then four-year-olds should use more lexical verbs to encode the mechanical support than Put Verbs. Given that six-year-olds and adults use lexical verbs to encode static mechanical support configurations (Landau et al., 2017; Johannes et al., 2016), they should continue to use lexical verbs (e.g., hang, stick, tape, etc.) in the current study.
2) If there is bias to encode such mechanical support events in terms of the spatial configuration (e.g., hang) vs. the mechanism of attachment (e.g., stick/tape), then participants should differentiate how they encode the mechanical support events and use verbs falling in one particular verb class the majority of the time (Verbs of Putting in a Spatial Configuration vs. Verbs of Attaching; see Table 1).

3) If Specific Verbs of Attaching are more likely to be used when a specific fastener is visible, then participants should use verbs such as 'tape,' 'clip,' 'pin,' but will use more General Verbs of Attaching (e.g., stick, attach) or Verbs of Putting in a Spatial Configuration (e.g., hang), when the fasteners are hidden.

Table 2

Summary of Predictions for the Current Study - Dynamic Support Events

Age	Visible Mechanism[a]
Four-year-olds	If similar to previous studies using static stimuli: Participants will use Put Verbs (put/place). If different from previous studies using static stimuli: Participants will use Lexical verbs (e.g., hang/stick/tape, etc.). • If bias to encode in spatial configuration: Participants will use Verbs of Putting in a Spatial Configuration (e.g., hang). • If bias to encode manner of attachment: Participants will use General or Specific Verbs of Attaching (e.g., stick, tape).
Six-year-olds	If similar to previous studies using static stimuli: Participants will use specific lexical verbs. • If bias to encode in spatial configuration: Participants will use Verbs of Putting in a Spatial Configuration (e.g., hang) • If bias to encode manner of attachment: Participants will use Specific Verbs of Attaching (e.g., tape, clip, etc.).
Adults	If similar to previous studies using static stimuli: Participants will use specific lexical verbs. • If bias to encode in spatial configuration: Participants will use Verbs of Putting in a Spatial Configuration (e.g., hang). • If bias to encode manner of attachment: Participants will use Specific Verbs of Attaching (e.g., tape, clip, etc.).

[a]The predictions for the hidden mechanism events are the same as the visible mechanical events except we predict that rather than using a specific verb of attachment to encode the manner, six-year-old children and adults may use a general lexical verb (hang, stick, attach) because the fastener is hidden.

Method

Participants

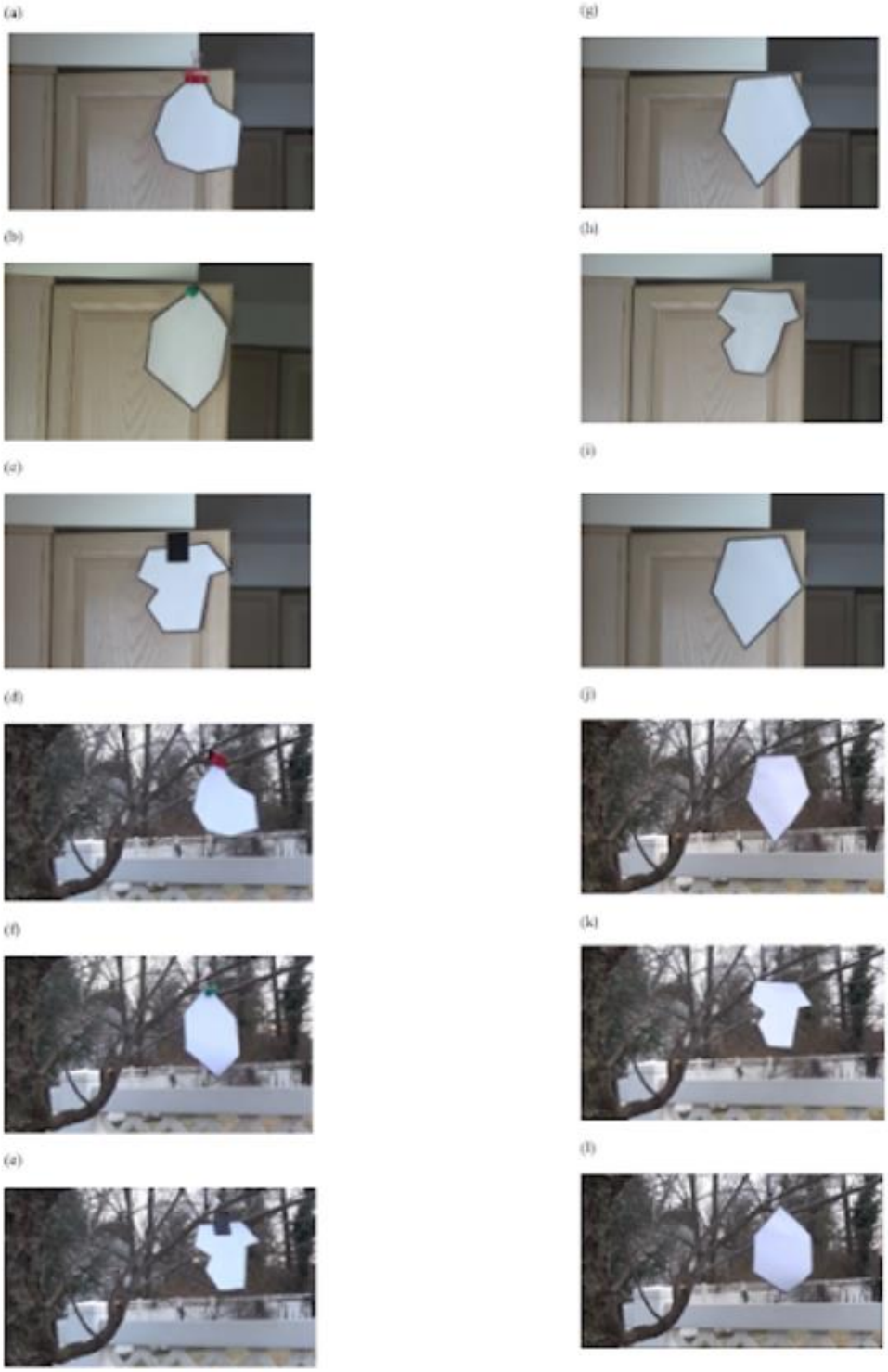
27 four-year-old (48 mo. - 59 mo.) and 27 six-year-old children (72 mo. - 83 mo.) (*M* age = 5 years; 3 months; Range: 4 years; 0 months to 6 years; 11 months; 28 males) and their mothers (*n* = 27) are included in the final sample. Four children were excluded from analysis due to being bilingual (n = 1), not understanding the task (n = 1), having a parent correct them (n = 1), and have delayed language development (n = 1). This sample size is based on a power analysis (G*Power 3.1; Faul Erdfelder, Buchner, & Lang 2009) of the pilot study (see below) using a similar method and same age participants with alpha = .05, power = .80, a medium effect size (f2 (V) = .5). Children's demographics (n=45, 9 parents did not report children's demographic data) were 4% Hispanic or Latino, 87% White, 2% Native American or Alaska Native, 9% Asian, and 2% Black or African American. Participants were recruited from community fairs, various social media groups, the Children Helping Science platform, and our lab's database. Participants were screened for eligibility based on birth after 37 weeks gestation, English as the first language, and no report of developmental delays. Data was excluded based on these predetermined criteria: complete less than the minimum of 50% of test trials (6 test trials), video errors in the participant recordings, or if a participant's parent provides the child with answers. The study protocol was approved by the University's Institutional Review Board.

Materials and Design

A novel battery of 12 dynamic events depicting mechanical support via attachment was created. Three mechanisms were included presenting taping via tape, clipping via clip, and pinning via pin (see Figure 1). The visibility of the attachment mechanism is an independent variable in the study, with two levels. In six events the tape/clip/pin is placed on the top of the figure and is in full view and in the other six events the tape/clip/pin is located on the back of the figure and completely hidden from view (see Figure 1). All the events are about 7.5-8 seconds long and first show the ground object (door or tree) (1.2 s) followed by a hand appearing on the screen and attaching (taping, clipping, or pinning) a figure object (piece of paper) to a ground object (door or tree) (3-4 s). The hand then retracts (0.30 s) showing only the figure and ground object (2.00 s). The videos have been imported into PowerPoint (videos are 4.92" x 7.5"). See https://drive.google.com/drive/folders/1_kRMlJOkUoUqTO7s46Z1308t_WKrNfpR?usp=sharing to view stimuli.

In addition to the 12 dynamic events displaying mechanical attachment, an additional four videos are included as filler items to deter participants from falling into a fixed pattern of responding when describing the support configuration. Two of the videos display a figure object *in* the ground object and the other two display the figure *under* the ground object. Furthermore, a dynamic video depicting a motion event (man rolling from a bin to a pillow) is included as a practice trial. Both practice and test trials are presented sequentially using PowerPoint. Test trials are randomized to create two orders, with the constraint that no more than two videos with the same ground object (tree/door) appear consecutively.

Figure 1



Note. Stimuli used for Experiments 1-3 separated by visible (left) and hidden (right) attachment mechanisms (i.e., fasteners): (a) and (b) visible clip, (c) and (d) visible pin, (e) and (f) visible tape, (g) and (h) hidden clip, (i) and (j) hidden pin, (k) and (l) hidden tape.

Procedure

Upon study confirmation, parents were provided with a modified language checklist created in our lab consisting of verbs and prepositions used by adults to describe various support configurations from previous research (Landau et al., 2017; 2018; see). The questionnaire consists of 10 items including prepositions and verbs that were used by children and adults to encode the events in our pilot study. Parents were asked to check off which words they believe their child understands and which words they produce spontaneously (i.e., without imitation) to assess children's comprehension and production of these verbs and prepositions (note that parents are told that these words are verbs and prepositions; see Appendix A). At the scheduled time of the study on Zoom, the experimenter reviewed key points of the consent form with the parent and asked the child if they wanted to participate with the Assent PowerPoint slides. The participants were asked to indicate if they want to participate by saying "yes" or giving a thumbs up.

The experimenter began the study by telling the participant, "We are starting the game now, but first I want to show you a funny video. After, I want you to tell me what happened." The participant viewed a practice video of a man rolling on the floor, and was asked "Can you tell me what happened?" The experimenter waited for the participant to respond; however, if they did not respond, the experimenter prompted the participant with "I am going to play the video again. I need you to tell me what happened." After the participant provided their response,

they watched a video introducing the paper toys used in the stimuli while the experimenter said, “Look at all the toys I have at my house! One day my sister was playing with my toys. Can you tell me what she did with them? Your job is to tell me what she did with my toys!” After the game was explained to the participant, the test trials began.

The procedure remained the same for each of the 12 test trials; the participant viewed a video of a toy being attached to a tree or to a door. When the video finished, the experimenter asked, “Can you tell me what my sister did with my toy?” After the participant responded, the experimenter said, “Great job! Let’s do some more!” If the participant did not respond during the test trial, the experimenter said, “I am going to play the video again. I need you to tell me what my sister did with my toy.” They would replay the video and prompt the participant again, “Can you tell me what my sister did with my toy?” Participants were encouraged throughout the test trials with statements such as, “Great job, keep going,” “You are doing great,” “You have a few more,” or “You are so good at this game.” During the experiment, the experimenter proceeded to the next test trial after the participant provided a description. The experimenter recorded which test trials the participant used a Put verb (e.g., put, or place). When the participant had completed all 12 test trials, if the participant used non-specific verbs in their descriptions, the experimenter went back to that trial and reviewed it with the participant. Specifically, the experimenter returned to each trial in order as they were first presented, re-played the video, and asked the participant, “Last time I showed you this video, you told me my sister “put” the toy xxx. Can you tell me what my sister did again without using the word ‘put’?” The experimenter repeated this prompt up to two times, to encourage the participant to use specific lexical verbs. If the participant continued to use a nonspecific lexical verb after being prompted twice, the experimenter proceeded to the next test trial that needed to be reviewed. The motivation for

including this 'review phase' of the experiment is to provide the participant with an opportunity to use a specific lexical verb (i.e., to provide a strong test of their competence). As explained below in *Results*, we will analyze the participant's final, or best, descriptions.

Once all the trials have been completed and, if necessary, reviewed with the participant, the experimenter will complete a post-test with the participant. The participants watched a video that presented them with the mechanisms (fasteners) used in the study. The experimenter said, "I want to show you a few things that you saw when we played the game! I am going to show you something and I want you to tell me what it is." The participant viewed three videos; each video will include one of the visible mechanisms used in the stimuli (black piece of tape, green pushpin, binder clip). Each time the participant viewed the mechanism, the experimenter asked, "Can you tell me what this is?" If the participant provided a correct response (e.g., tape, clip, or pin), the experimenter said, "Great job!" If the participant provided an incorrect response, the experimenter said, "Thank you for using your words, but look closely, can you tell me again what this is?" If the child said that they did not know what the mechanism was the experimenter said, "That's okay. It is a tape/clip/pin." The motivation for including this 'post-test phase' is to assess children's knowledge of the objects' names that are used as support mechanisms in the study. Clip, tape, and pin are instances that occur as a noun and verb in English. It's possible that children's use of specific lexical verbs such as clip, tape, and pin will be related to their knowledge of these nouns (and knowledge of these nouns may be inversely related to the use of more general attachment verbs, such as 'stick' or verbs of putting, such as 'hang'). As we explain in *Results* below, we will test this possibility in our analyses. After the participant has completed the post-test, the experimenter will begin the adult portion of the study with the child's parent/guardian using the *exact* same method described above.

Pilot Data

We collected pilot data on 4- and 6-year-old children and adults to affirm that the method for Experiment 1 is effective, as well as to inform our proposed coding of the data. We presented children and adults with dynamic videos of attachment configurations. The pilot sample consisted of 28 participants, including 6 four-year-olds, 10 six-year-olds, and 12 adults (research assistants and parents). Three children were excluded from the sample, one due to being bilingual, one not being on task (e.g., being distracted during most test trials), and one due to video errors in the participant's recording. The method was highly similar to Experiment 1 with the following exceptions. The stimuli only included 2 mechanisms (tape and clip) and one ground (door) (paper taped/clipped to the door) (see Figure 1). Also, the prompting for the specific lexical verb was not a separate phase of the experiment, but rather, if the participant did not use a specific verb, they were prompted immediately after their first description. Participants' descriptions were transcribed, and coding categories based on Verb types in Table 1 were created (same as Experiment 1). We present only the first description pilot data since there was no difference in the pattern of means for first and final descriptions across all three age groups. The majority of adults' descriptions included VPs that were Verbs of Attaching; Specific Verbs of Attaching when the mechanism is visible (e.g., tape, clip) and General Verbs of Attaching when the mechanism is hidden (stick, attach). Four-year-olds in contrast show a very different pattern, with most of their descriptions including VPs that were Verbs of Putting in a Spatial Configuration, mostly "hang," for both the visible and hidden mechanism trials. Six-year-olds fall in the middle of the children and adults, with most of their descriptions including a Specific Verb of Attaching ("clip" and "tape") for the visible mechanism events. For the hidden events, 6-year-olds did not show a particular preference for any VP class. Given these findings, we affirm the method the effective. Note that the current study makes several changes from the pilot study,

such as an additional ground object, a third mechanism (pin), and the re-test was conducted after all the test trials have been presented to the participant.

Results

Coding

Children's speech were transcribed from the video recordings and coded by a trained research assistant. The transcriptions were coded in terms of the full Verb Phrase (VP; Verb + Preposition). Guided by linguistic analyses (Levinson & Wilkins, 2006; Levin, 1993) and informed by a pilot study (see above), the VPs were coded as either 1) Put Verbs, that is, put and place, 2) Verbs of Putting in a Spatial Configuration, such as hang and dangle, 3) General Verbs of Attaching, such as stick and attach (i.e. verbs that do not encode a specific fastener), 4) Specific Verbs of Attaching, such as tape, clip, pin, (i.e., those that encode specific fasteners), 5) Other, which will include VPs that do not fall into one of the first five categories, and 6) No VP, which will include descriptions in which a VP was omitted. A second trained research assistant will code 50% of the entire set of transcriptions in terms of the full Verb phrase as well as which category (1-6 above) it falls into.

Lexical Verb Use in Participants

We report the descriptives for all the VP coding categories in Table 1 for both first and final responses (see Table 3). For each coding category, a proportion was calculated out of the number of test trials each participant completed for first and final responses. This was done separately for visible and hidden events. Regarding the first responses for visible events, four-year-olds used Put Verbs (M = 0.37; SE = .07) and Verbs of Putting in a Spatial Configuration (M = 0.30; SE = .06) most. Six-year-olds also used Put Verbs (M = 0.43; SE = .08), frequently in

their responses followed by Specific Verbs of Attaching (*M* = 0.31; *SE* = .07) and Verbs of Putting in a Spatial Configuration (*M* = 0.20; *SE* = .05). In contrast, adults used Specific Verbs of Attaching most of the time (*M* = 0.90; *SE* = .03), which is line with our predictions. However, responses change following the re-test. Regarding final responses, four-year-olds still use Verbs of Putting in a Spatial Configuration (*M* = 0.32; *SE* = .07) frequently, followed by Specific Verbs of Attaching (*M* = 0.27; *SE* = .06) and Put Verbs (*M* = 0.27; *SE* = .08), suggesting that they still use the BLC as in static stimuli and start to extend their use of lexical verbs. Further, six-year-olds use Put Verbs less and instead use Specific Verbs of Attaching (*M* = 0. 37; *SE* = .05) and Verbs of Putting in a Spatial Configuration (*M* = 0.27; *SE* = .05) more, which is in line with the predictions in Table 2. Adult responses remain the same with most using Specific Verbs of Attaching (*M* = 0.90; *SE* = .02).

Regarding first responses for hidden events, four-year-olds use Put Verbs (*M* = 0.42; *SE* = .07) and Verbs of Putting in a Spatial Configuration (*M* = 0.29; *SE* = .07) the most, similar to their descriptions of visible events. Similarly, six-year-olds use Put Verbs (*M* = 0.61; *SE* = .08) the most to describe hidden events. In contrast, adults use General Verbs of Attaching (*M* = 0.55; *SE* = .07) and Specific Verbs of Attaching (*M* = 0.31; *SE* = .06) in most of their responses. This is consistent with our predictions that adults would use lexical verbs, specifically general verbs of attaching to encode hidden events. Following the re-test, the final responses for four-year-olds and adults remain similar to the first response, but the responses for the six-year-olds changed. Four-year-olds use Put Verbs (*M* = 0.31; *SE* = .07) and Verbs of Putting in a Spatial Configuration (*M* = 0.31; *SE* = .08) the most, and adults use General Verbs of Attaching (*M* = 0.54; *SE* = .07) and Specific Verbs of Attaching (*M* = 0.34; *SE* = .07) the most. Six-year-olds used a variety of verbs in their final responses with Specific Verbs of Attaching (*M* = 0.38; *SE* =

.07) and Put Verbs (*M* = 0.20; *SE* = .06) being used the most. Across events, adults pattern differently than 4-and 6-year-olds, however we do not see many differences between 4-and 6-year-olds.

Table 3

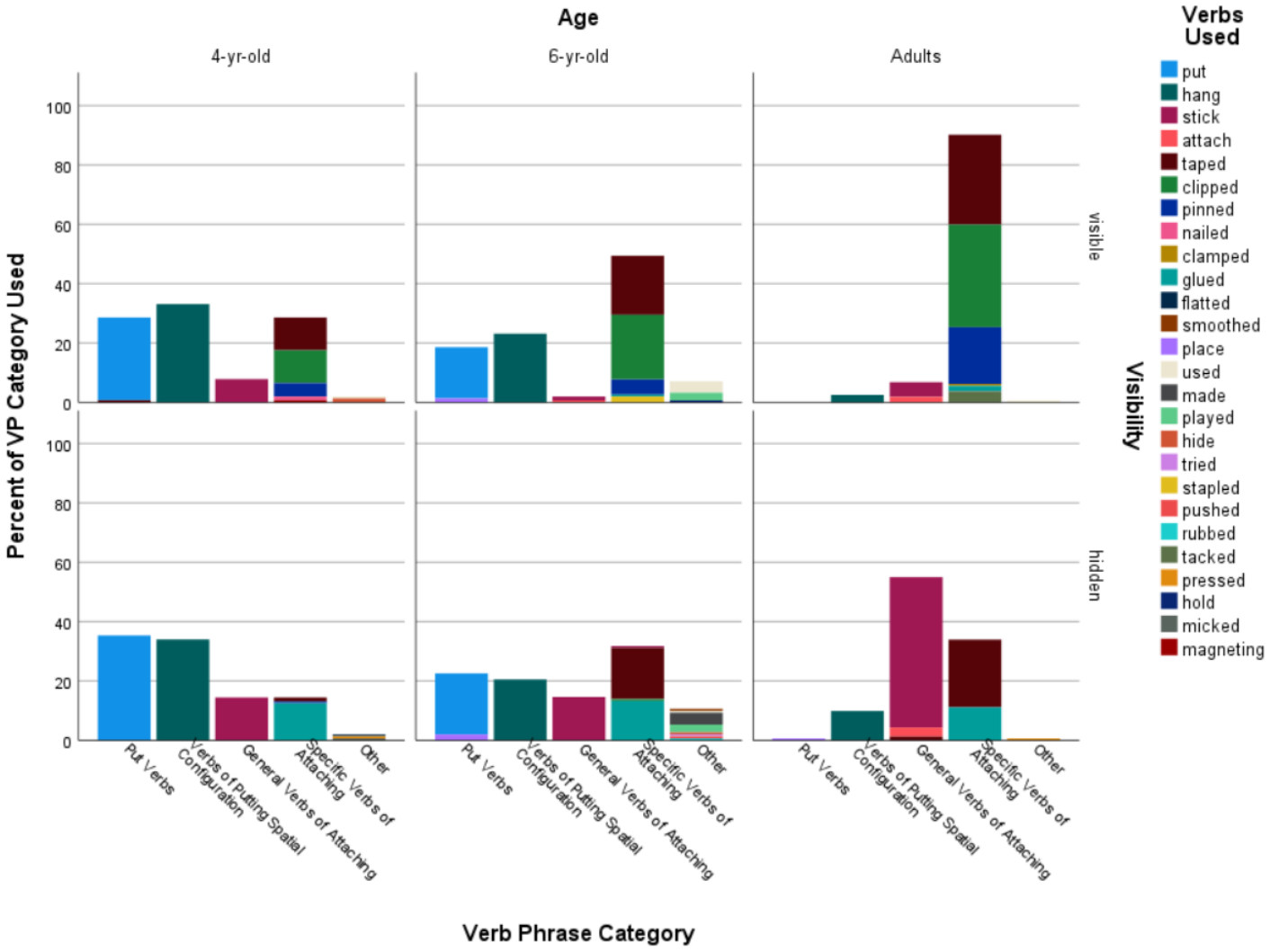
Descriptives for Verb Category Use

Verb Category	4-yr-olds	6-yr-olds	Adults
First Response			
Visible Events			
Put Verbs	0.37 (*0.07*)	0.43 (*0.08*)	0.01 (*0.01*)
Spatial Configuration Verbs	0.30 (*0.06*)	0.20 (*0.05*)	0.02 (*0.01*)
General Verbs of Attaching	0.07 (*0.04*)	0.01 (*0.01*)	0.06 (*0.02*)
Specific Verbs of Attaching	0.24 (*0.06*)	0.31 (*0.07*)	0.90 (*0.03*)
Other Verbs	0.01 (*0.01*)	0.01 (*0.01*)	0.01 (*0.01*)
No Verb Phrase	0.01 (*0.01*)	0.04 (*0.03*)	0.00 (*0.00*)
Hidden Events			
Put Verbs	0.42 (*0.07*)	0.61 (*0.08*)	0.04 (*0.03*)
Spatial Configuration Verbs	0.29 (*0.07*)	0.15 (*0.06*)	0.09 (*0.03*)
General Verbs of Attaching	0.13 (*0.06*)	0.08 (*0.04*)	0.55 (*0.07*)
Specific Verbs of Attaching	0.13 (*0.05*)	0.08 (*0.04*)	0.31 (*0.06*)
Other Verbs	0.01 (*0.01*)	0.06 (*0.04*)	0.01 (*0.01*)
No Verb Phrase	0.02 (*0.01*)	0.02 (*0.02*)	0.00 (*0.00*)
Final Response			
Visible Events			
Put Verbs	0.27 (*0.08*)	0.23 (*0.05*)	0.01 (*0.01*)
Spatial Configuration Verbs	0.32 (*0.07*)	0.27 (*0.05*)	0.02 (*0.01*)

General Verbs of Attaching	0.07 (*0.04*)	0.02 (*0.01*)	0.07 (*0.02*)
Specific Verbs of Attaching	0.27 (*0.06*)	0.37 (*0.05*)	0.90 (*0.02*)
Other Verbs	0.02 (*0.01*)	0.06 (*0.03*)	0.00 (*0.00*)
No Verb Phrase	0.05 (*0.03*)	0.05 (*0.03*)	0.00 (*0.00*)
Hidden Events			
Put Verbs	0.31 (*0.07*)	0.20 (*0.06*)	0.01 (*0.01*)
Spatial Configuration Verbs	0.31 (*0.08*)	0.17 (*0.05*)	0.10 (*0.03*)
General Verbs of Attaching	0.14 (*0.06*)	0.13 (*0.05*)	0.54 (*0.07*)
Specific Verbs of Attaching	0.15 (*0.06*)	0.38 (*0.07*)	0.34 (*0.07*)
Other Verbs	0.03 (*0.01*)	0.07 (*0.03*)	0.01 (*0.01*)
No Verb Phrase	0.06 (*0.03*)	0.05 (*0.03*)	0.00 (*0.00*)

Note. Note that the means for each age group are reported with the (standard errors). Both first and final responses are reported and separated by visible and hidden events.

Figure 2 Final Response Percentage of use of verb type categories (X axis) and specific verbs (color coded - see legend) across visible (top row) and hidden (bottom row) mechanisms and age: four-year-olds (far left column), six-year-olds (middle column), Adults (far right column)



Likelihood of Using VP Categories by Age and Visibility

The rest of the analyses will only use participants' final responses, as they are the best response reflecting participants' knowledge of these mechanisms. Next, to address two of our research questions 1) will four-year-olds use more lexical verbs compared to previous research using static stimuli, and 2) will the support mechanism visibility effect the verbs used by participants, we conducted a mixed effects logistic regression analysis on participants' likelihood to include a particular verb class in their description in SPSS Version 29. The data was coded in terms of 1/0 for each verb type (1 = participant used verb type, 0 = participant did not use verb type). Mechanism visibility (visible vs hidden) and Age group (4-years, 6-years, vs. Adults) were entered as fixed factors; the model included random intercepts for Participants. Tests for interactions among the two independent variables were conducted as exploratory analyses. We conducted four models in total – one for each verb type (i.e., Put verbs, Verbs of Putting in a Spatial configuration, General Verbs of Attaching, and Specific Verbs of Attaching; see Table 1); 'Other Verbs' and 'Verb Omissions' are reported in Table 3 but not entered into the analyses below.

In the first model using Put Verbs as the target, there was a significant effect of Age on the likelihood of Put Verbs (e.g., put, place) being used in participants' descriptions, four-year olds (β= 5.03, 95% CI = 2.35 – 7.07, p <.001) and six-year-olds (β= 4.21, 95% CI = 1.52 – 6.89, p = .002) were more likely to use Put Verbs in their descriptions compared to adults. When four-year-olds were treated as the reference category, there were no significant differences in the use of Put Verbs between four- and six-year-olds. There was a significant effect of Visibility such that participants were less likely to use Put Verbs to describe visible events (β= -0.548, 95% CI = -1.06 - -0.03, p = .036). Further, there were no significant interactions between Age and Visibility (see Table 4). Consistent with our predictions, Age was a significant factor, in that

four- and six- year olds are more likely to use Put Verbs compared to adults, however there was no difference between four-and six-year-olds. We found that Visibility is a significant factor suggesting that seeing the mechanism of support (visible events) decreases the likelihood of participants using verbs such as “put” or “place”.

Table 4

Likelihood to Use Put Verbs by Age and Visibility

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Fixed coefficients					
Intercept	-5.989	1.12	3.50	7.93	.000
Age: 4	5.03	1.21	-6.69	-1.93	.000
Age: 6	4.21	1.24	-6.34	-1.44	.002
Age: Adults	.	.	.	.	.
Visibility: Visible	-0.55	.285	-.132	-.988	.036
Visibility: Hidden	.	.	.	.	.
4-yr-olds * visible	-12.77				.987
4-yr-olds * hidden	.	.	.	.	.
6-yr-olds * visible	-13.014				.987
6-yr-olds * hidden	.	.	.	.	.
Adults * visible	.	.	.	.	.
Adults * hidden	.	.	.	.	.

Note. Target = Put Verbs. Total *N* = 12420. Included *N* = 971. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The second model used Verbs of Putting in a Spatial Configuration as the target to examine the likelihood of participants using verbs such as "hang" in their descriptions (second row of Table 3). There was a significant effect of Age in that four-year-olds olds (β= 2.12, 95% CI = 0.832 – 3.40, p = .001) and six-year-olds (β= 1.46, 95% CI = 0.171 – 2.75, p = .027) were more likely to use "hang", compared to adults. When four-year-olds were treated as the reference category, there were no significant differences between four-and-six-year-olds. Visibility was not a significant factor in this model. When exploring the data, there was a significant interaction between Age and Visibility in that compared with adults and hidden events, four-year-olds used "hang" more to describe visible events (β= 1.62, 95% CI = 0.27 – 2.96, p = .018), as did six-year-olds (β= -1.89, 95% CI = 0.56 – 3.24, p = .006) (see Table 5). When four-and-six year olds use lexical verbs, they are more likely to include "hang" in their descriptions, specifically to describe visible events, compared to adults. We predicted that Verbs of Putting in a Spatial Configuration could be used to describe hidden events more, yet the model suggests that children use "hang" more to describe visible events.

Table 5

Likelihood to Use Verbs of Putting in a Spatial Configuration by Age and Visibility

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Fixed coefficients					
Intercept	-3.26	0.51	-4.26	-2.26	<.001
Age: 4	2.12	0.65	0.83	3.40	.001
Age: 6	1.46	0.66	0.17	2.75	.027
Age: Adults	.	.	.	.	.
Visibility: Visible	-0.16	0.21	-0.58	0.26	.454

Visibility: Hidden	.	.	.	.	.
4-yr-olds * visible	1.616	0.68	0.27	2.96	.018
4-yr-olds * hidden	.	.	.	.	.
6-yr-olds * visible	1.89	0.68	0.56	3.24	.006
6-yr-olds * hidden	.	.	.	.	.
Adults * visible	.	.	.	.	.
Adults * hidden	.	.	.	.	.

Note. Target = Verbs of Putting in a Spatial Configuration. Total *N* = 12420. Included *N* = 971. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The third model used General Verbs of Attaching as a target to examine the likelihood of participants using verbs such as “stick” and “attach” in their descriptions (3rd row of Table 3). There were significant effects of Age and Visibility (see Table 6). Four-year-olds (β= -2.47, 95% CI = -3.81 – -1.12, p <.001) and six-year-olds (β= -2.59, 95% CI = -3.93 – -1.26, p < .001) were less likely to use verbs such as “stick” and “attach” in their descriptions compared to adults. Further, there were no significant differences between four- and six-year-olds. Visibility was significant in that General Verbs of Attaching were less likely to be used for visible events (β= -2.92, 95% CI = -3.50 - -2.33, p < .001). We explored the data to examine interactions, and there was a significant interaction between Age and Visibility in four-year-olds in that General Verbs of Attaching were used less frequently to describe visible events (β= -2.22, 95% CI = -3.58 – -0.86, p = .001), however no other interactions were significant. Further, there were no significant differences between four- and six-year olds. Consistent with this model, adults used General Verbs of Attaching more frequently than four- and six-year-olds. Further, Visibility was a

significant factor in that General Verbs of Attaching were used more frequently to describe hidden events, providing further support that visibility of the mechanism will impact participants' verb usage such that more general verbs will be sued when the mechanism of attachment is ambiguous.

Table 6

Likelihood to General Verbs of Attaching by Age and Visibility

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Fixed coefficients					
Intercept	0.04	0.44	-0.82	0.89	.083
Age: 4	-2.47	0.68	-3.81	-1.12	<.001
Age: 6	-2.59	0.68	-3.93	-1.26	<.001
Age: Adults	.	.	.	.	.
Visibility: Visible	-0.16	0.21	-0.58	0.26	.454
Visibility: Hidden	.	.	.	.	.
4-yr-olds * visible	-2.22	0.68	-3.58	-.86	.001
4-yr-olds * hidden	.	.	.	.	.
6-yr-olds * visible	-0.88	0.83	-2.50	0.75	.290
6-yr-olds * hidden	.	.	.	.	.
Adults * visible	.	.	.	.	.
Adults * hidden	.	.	.	.	.

Note. Target = General Verbs of Attaching. Total N = 12420. Included N = 971. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

The fourth, and final model, examined the likelihood of using Specific Verbs of Attaching (e.g., tape, clip, pin) in participants' responses (row 4 of Table 3). There was an effect of Age and Visibility (see Table 7). Compared to adults, four-year-olds (β= -3.05, 95% CI = -4.16 – -1.94, p < .001) and six-year-olds (β= -1.59, 95% CI = -2.66 – -0.54, p = .003) were less likely to use verbs like "tape", "clip", "pin". When four-year-olds were treated as the reference category, there was a significant difference between four-and six-year-olds such that six-year-olds were more likely to use Specific Verbs of Attaching (β= 1.45, 95% CI = 0.343 – 2.56, p = .0). Further, Specific Verbs of Attaching were more likely to be used to describe visible events (β= 2.06, 95% CI = 1.69 – 2.44, p <.001). In the exploratory analyses, there was a significant interaction between Age and Visibility. Four-year-olds were more likely to use Specific Verbs of Attaching to describe visible events (β= 2.39, 95% CI = 1.31 – 3.48, p < .001) as were six-year-olds (β= 2.72, 95% CI = 1.76 – 3.67, p < .001). Consistent with our predictions, adults and six-year-olds were more likely to use Specific Verbs of Attaching, as we predicted they would use more lexical verbs. Additionally, Visibility was significant consistent with our predictions that participants will use verbs that name the mechanism/fastener in visible events compared to hidden.

Table 7

Likelihood to Specific Verbs of Attaching by Age and Visibility

Effect	Estimate	*SE*	95% CI		*p*
			LL	*UL*	
Fixed coefficients					
Intercept	-0.23	0.39	-0.99	0.531	.554

Age: 4	-3.05	0.68	-4.16	-1.94	<.001
Age: 6	-1.59	0.68	-2.66	-.536	.003
Age: Adults	.	.	.	.	.
Visibility: Visible	2.06	0.21	1.69	2.44	<.001
Visibility: Hidden	.	.	.	.	.
4-yr-olds * visible	2.39	0.55	1.31	3.48	<.001
4-yr-olds * hidden	.	.	.	.	.
6-yr-olds * visible	2.72	0.48	1.76	3.67	<.001
6-yr-olds * hidden	.	.	.	.	.
Adults * visible	.	.	.	.	.
Adults * hidden	.	.	.	.	.

Note. Target = Specific Verbs of Attaching. Total *N* = 12420. Included *N* = 971. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Bias to Encode Spatial Configuration OR Manner of Attachment

Next, we address our research question about whether participants have a bias to encode the resulting spatial configuration (i.e., with verbs like hang) or the manner of attachment (i.e., with verbs like stick, clip). The descriptive statistics and analyses above shed light on whether there is a bias, but in order to test that more directly, the data was coded into two broader coding categories: Verbs of Putting in a Spatial Configuration (Category 2 in Table 1) and Verbs of Attaching (Categories 3 and 4 in Table 1) (and in Table 3, rows 2 vs. rows 3 and 4). For each age group separately, and for the visible and hidden events separately, a Chi Square Test of Independence was conducted to test whether the distributions of these two broad categories significantly differ from each other. If there is a bias to encode the events in terms of the resulting spatial configuration OR the manner, these Chi Squares should be significant, and the

patterns of the means will suggest how they differ. The proportion of four-year-olds that used Verbs of Putting in a Spatial Configuration and Verbs of Attaching to describe visible events showed a significant bias to encode the manner of attachment, X^2 (1, N = 162) = 40.46, p <.001. Six-year-olds also show a significant bias to use Verbs of Attaching to describe visible events, X^2 (1, N = 162) = 45.16, p <.001. Similarly, when shown visible events, adults show a significant bias to use Verbs of Attaching, X^2 (1, N = 162) = 128.78, p <.001. These results suggest that four-year-olds, six-year-olds and adults show a bias to encode the mechanism of attachment over the resulting spatial configuration when presented with events where the mechanism is visible.

We conducted the same analyses with hidden events. There was a significant difference in the proportion of four-year-olds that used Verbs of Putting in a Spatial Configuration, and Verbs of Attaching in that four-year-olds showed a bias to use Verbs of Putting in a Spatial Configuration, X^2 (1, N = 162) = 28.88, p <.001 to describe hidden events. In contrast, six-year-olds, X^2 (1, N = 162) = 29.17, p <.001 and adults, X^2 (1, N = 162) = 142.03, p <.001 showed a significant bias to use Verbs of Attaching. These results suggest that four-year-olds show a significant bias to encode the manner of attachment when shown visible events, however when shown hidden events 4-year-olds show a bias to encode the resulting spatial configuration. Whereas, six-year-olds and adults show a significant bias to use Verbs of Attaching for both visible and hidden events, suggesting that both six-year-olds and adults tend to encode the manner or mechanism of attachment.

Additional analyses: Correlations of Children's Verb Use

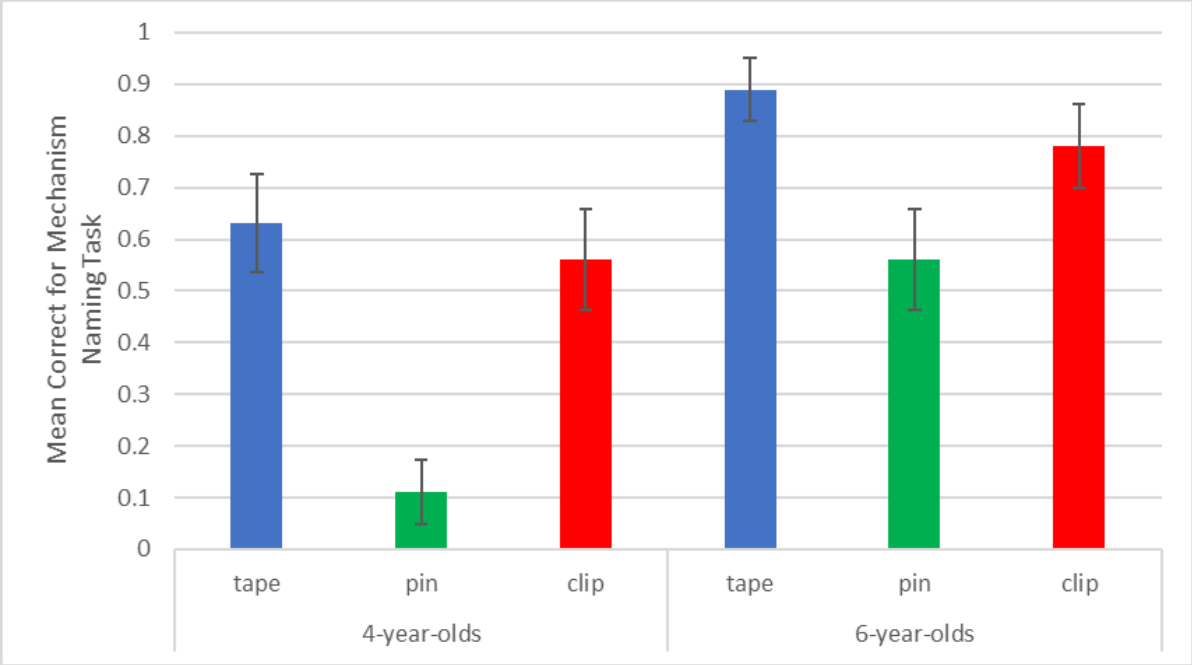
As described in the Method, two additional measures were administered to explore children's acquisition of lexical support verbs. These measures are a post-test of children's noun

knowledge of the mechanisms (tape, clip, pin) and a parent checklist asking parents to report their child's knowledge of the lexical verbs.

In the post-test of children's knowledge of the mechanisms, children received a score of 1 if they correctly labeled the mechanism during post-test (and 0 if they did not) for each mechanism. Four-year-olds correctly named tape 63%, clip 56% and pin 11%. Six-year-olds correctly named tape 89%, clip 78%, and pin 56%. To explore the relationship between the child's use of the lexical verbs (tape, clip, and pin) in the experiment with their noun knowledge for each mechanism, a point biserial correlation was conducted. If noun and verb knowledge of these mechanisms are related, then a significant positive correlation is expected across children. The correlation suggests that there is a significant positive relationship between children's use of Specific Verbs of Attaching (tape, clip, and pin) and their knowledge of clips, $r(54) = .440$, $p = <.001$ and pins, $r(54) = .276$, $p = .043$, but not tape, $r(54) = -0.01$, $p = .919$.

Figure 3

Post-Test Naming Task



Note: The means for the post-test naming task (Y axis) separated by 4-and 6-year-olds for each mechanism (X axis). The error bars reflect the standard error.

The parent checklist was administered to children's parents, and children received a score of 1 if their parent judged that they understood and produced the verb (and 0 if they did not). A point biserial correlation was conducted to explore the relationship between the child's use of the lexical verbs (tape, clip, and pin) in the visible event trials with their reported knowledge of these verbs (by their parents), for each mechanism type. If the parent report is a reliable indicator of children's knowledge, a significant positive correlation is expected. Note that 4 children (3 six-year-olds and 1 four-year-old) are not included in these analyses due to parents either not completing the checklist, or not answering all the items, resulting in data for 50 children. Parents indicated that their children understood tape, clip, and pin. Parents reported that 92% of their children could understand and produce tape, 82% could understand and produce clips, 78% could understand and produce pin. There were only one significant correlation, such that

children's use of specific lexical verbs (tape, clip, and pin) is was related to the parent reported knowledge of tape, $r(54) = -0.282$, $p = .047$ This suggests that the parent report may not be a reliable indicator of children's knowledge of these mechanism labels.

Discussion

The current study examines how children develop language within the domain of mechanism support. We asked if four-year-olds will prefer the Basic Locative Construction ('put'/ 'place' on) to encode dynamic events of mechanical support as shown in previous research using static configuration (Landau et al., 2017; Johannes et al., 2016). Or will four-year-olds use more specific verbs that encode support given that dynamic events may elicit more lexical verbs, and within this is there a bias to encode the end result spatial configuration ("hang") or the manner of attachment ("stick", "tape", clip"). We predicted six-year-olds and adults will use lexical verbs similar to previous studies (Landau et al., 2017; Johannes et al., 2016) to encode mechanical support. The results suggest that four-year-olds use lexical verbs more than previous research using static stimuli, and that six-year-olds and adults use lexical verbs often, similar to previous studies. For example, compared to our findings, previous research using static stimuli report that four-year-olds used lexical verbs overall 4% of the time (Landau et al., 2017) and another study reported that they use lexical verbs 3.13% to encode hanging, 4.69% to encode point-attachment, and 0% to encode adhesion (Johannes et al., 2016). Further, the logistic regression model suggests that four- and six-year-olds are more likely to use verbs such as "put" and "place" and are less likely to use General and Specific Verbs of Attaching compared to adults. Further, we did not find any significant differences between four- and six-year-olds in their use of verb categories, except for the Specific Verbs of Attaching such

that six-year-olds used verbs such as “tape”, “clip”, and “pin” more than four-year-olds. Overall, the means of verbs used suggest that lexical verbs are used often by all participants.

We also asked if there is a bias to encode the spatial configuration (e.g., hang) vs. the mechanism of attachment (e.g., stick/tape), and if there is a bias, then participants will differentiate how they encode mechanical support events by using one class of verbs over another (Verbs of Putting in a Spatial Configuration versus Verbs of Attaching). We also asked if visibility would impact participants verb usage such that if Specific Verbs of Attaching may be likely to be used when a specific fastener is visible, then participants should use verbs such as ’tape,’ ‘clip,’ ‘pin,’ whereas General Verbs of Attaching (e.g., stick, attach) or Verbs of Putting in a Spatial Configuration (e.g., hang), when the fasteners are hidden. Our results suggest that, when encoding visible events, four-year-olds, six-year-olds and adults show a bias to use Verbs of Attaching (e.g., tape, clip, pin), suggesting a preference to encode the manner of attachment over the resulting spatial configuration. This is consistent with our predictions that visibility will play a role in the lexical verbs used such that when the mechanism is visible, participants use verbs that encode the mechanism or fastener accomplishing the support. When encoding hidden events, four-year-olds show a bias to use Verbs of Putting in a Spatial Configuration (hang), whereas six-year-olds and adults show a bias to use Verbs of Attaching suggesting that the visibility of the mechanism may impact what verb class is used by four-year-olds. Four-year-olds tend to encode the mechanism of attachment in visible events but encode the resulting spatial configuration in hidden events consistent with our predictions.

Our additional analyses examined the relationship between the post naming task and the parent report, and children’s use of Specific Verbs of Attaching. The results show that the naming task and children’s responses were significant for the “clip” and “pin” trials. Given that

children correctly named “tape” the most, it is interesting that “clip” and “pin” were significant. Further, it is interesting that the parent report of “tape” knowledge was only significantly correlated to children’s responses. This suggests that parents may report that children have different knowledge of these mechanisms than was reflected by children’s responses in our study.

Given our results, we reflect on how these results may shed light on language development, verb knowledge and how young children reason about physical events. Lexical verb usage in four-year-olds suggests that they, like six-year-olds and adults, have differentiated semantic understanding of different support categories. Four-year-olds’ verb knowledge suggests that they also have an understanding of these mechanisms as objects and as actions accomplishing support. Further, four-year-olds not only show knowledge and understanding of one mechanism, but many, including the three we used in our study by using a variation of Specific Verbs of Attaching (e.g., tape, clip, pin, nailed, glued). Previous research suggested that four-year-olds would choose a response with a lexical verb over BE/put on when presented with both options (Johannes et al., 2016), but our findings extend this in that they shed light on how four-year-olds can produce these verbs often. This relates to another key finding of our study such that dynamic events may elicit more lexical verbs and allow for the force dynamic forces to be more salient for participants, especially four-year-olds. Some support types may be accurately captured in static configurations (e.g., support from below), whereas mechanical support such as hanging, and attachment may be best presented using dynamic events. Dynamic events may bring more attention to the mechanisms involved. Compared to six-year-olds and adults, four-year-olds may require the perceptual cues presented in dynamic events to produce lexical verbs. However, more research needs to examine the role of motion in dynamic events. We provide

some evidence here that dynamic events elicit more lexical verbs, however we are currently testing this more directly.

Our results also shed light on four-year-olds' ability to infer about support mechanisms. As discussed above, four-year-olds have a bias to use Verbs of Attaching (e.g., stick, tape) to encode visible events with our regression models suggesting that Specific Verbs of Attaching (e.g., tape, clip, pin) were more likely to be used for visible events. When the support mechanism is visible, participants infer that the mechanism is accomplishing the support and reflect that in the lexical verbs used. In contrast, unlike six-year-olds and adults that prefer to use Verbs of Attaching for both visible and hidden events, four-year-olds show a bias to use Verbs of Putting in a Spatial Configuration (e.g., hang) by encoding the resulting spatial configuration. This result is particularly interesting regarding four-year-olds' ability to infer about *hidden* mechanisms. If four-year-olds use verbs such as "hang", then they are not inferring about a causal mechanism rather they are encoding the location within a spatial configuration. Although there is a bias to use verbs such as "hang", about 19% of participants use Verbs of Attaching with 15% being Specific Verbs of Attaching (e.g., tape, clip, pin, glue) suggesting that some four-year-olds infer about a mechanism in hidden events. Interestingly, when examining the data and the verbs used, we see that when Specific Verbs of Attaching are used to describe hidden events, the most used verb is "glued" which encodes a mechanism that is usually hidden, compared to clips or pins that are typically visible in configurations. Further, this is reflective of the pattern seen in six-year-old and adults that have a bias to use Verbs of Attaching, and when they use Specific Verbs of Attaching, they use "glued" and "taped" the most.

Our study expands upon previous studies by using dynamic stimuli to better elicit lexical verbs. Unlike previous studies we controlled for how the mechanism of support is presented in

that we ensured that the mechanism was a third object in the configurations (e.g., figure object, ground object, and mechanism) even when the mechanism was covered, rather than the mechanism being a property of the figure or ground objects (e.g., sticky note). Our results shed light on language development of the verbs used to encode mechanical support, but our results are limited due to several reasons. Firstly, the children involved in this study are monolingual English speakers, therefore these results may not apply to bilingual children as different languages encode support differently. This is currently a research question we are exploring in our lab. Secondly, we only examined three mechanisms (tape, clip, pin), but there are many different mechanisms that all vary in their use and the manner in which they are encoded (e.g., magnets, glue). These mechanisms involve different force dynamics and children may acquire the language for these mechanisms/fasteners differently compared to the three we examined. Thirdly, we measured children's language use and knowledge of the names of "tape", "clips", and "pins", but we did not measure children's exposure to these mechanisms. There are many ways in which children may acquire the language used to encode support, especially Specific Verbs of Attaching. Children may have experience playing or using tape, clips, and pins at home or in school, which can provide them with a better understanding of how these mechanisms can be used to accomplish support.

Our study used novel dynamic events to examine children's language development, and we found that four-year-olds use more lexical verbs when presented with dynamic stimuli and that six-year-olds and adults continue to use these verbs. Further we provide evidence suggesting that visibility of the support mechanism plays a role in participants' verb usage. We also examined if there is a bias to encode the resulting spatial configuration (use Verbs of Putting in a Spatial Configuration) or the manner of attachment (use Verbs of Attaching). We found that

four-and six-year olds and adults have a bias to encode the manner of attachment by using Verbs of Attaching more for visible events, but when shown hidden events four-year-olds have a bias to encode the resulting spatial configuration by using Verbs of Putting in a Spatial Configuration more, whereas six-year-olds and adults have a bias to encode the manner of attachment. Our findings have implications for children's language development and reasoning about physical events. Specifically, the results suggest that four-year-olds have knowledge about support mechanisms. The data suggests that dynamic events elicit more lexical verbs by bringing more attention to the force-dynamics in support configurations. Further, the data has implications for how children infer about hidden mechanisms involved in physical support events.

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Appendix A

Please write your name.

The following is a list of typical words in young children's vocabularies. For word your child understands but does not yet say, place a mark in the first column (understands). For words your child not only understands but also says, place a mark in the second column (says). If your child uses a different pronunciation of the word (for example, "raffe" for "giraffe" or "sketti" for "spaghetti"), mark the word anyway. If they do not say or understand the word, please mark "does not understand or say." Remember, this is a "catalogue" of words that are used by many children. Don't worry if your child knows only a few right now.

Please note that the words listed below are prepositions and verbs (e.g., the picture *is on* the wall; the note *sticks to* the wall).

	Understands	Understands and Says	Does not understand or say
hang	☐	☐	☐
stick	☐	☐	☐
clip	☐	☐	☐
tape	☐	☐	☐
pin	☐	☐	☐
on	☐	☐	☐
onto	☐	☐	☐
to	☐	☐	☐
in	☐	☐	☐
into	☐	☐	☐
off	☐	☐	☐
from	☐	☐	☐
out	☐	☐	☐