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The role of timing and prototypical causality on how preschoolers fast-map novel verb meanings

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Abstract

In controlled contexts, young children find it more difficult to learn novel words for actions than words for objects: Imai et al. found that English-speaking three-year-olds mistakenly choose a novel object as a referent for a novel verb about 42% of the time despite hearing the verb in a transitive sentence. The current two studies investigated whether English three- and five-year-old children would find resultative actions easier (since they are prototypically causative) than the non-resultative, durative event types used in Imai et al.'s studies. The reverse was true. Furthermore, if the novel verbs were taught on completion of the action, this did not improve performance, which contrasts with previous findings. The resultative actions in the two studies reported here were punctual, change-of-location events which may be less visually salient than the non-resulative, durative actions. Visual salience may play a greater role than does degree of action causality in the relative ease of verb learning even at three years.

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Introduction

Children learn a large number of names for objects at a surprisingly young age and often with surprisingly few exemplars (e.g. Fenson et al., 1994; see Childers & Tomasello, 2006, for a review). Words for actions, in contrast, are relatively difficult to learn (e.g. Childers & Tomasello, 2002; Gentner, 1982, 2006; Imai, Haryu, & Okada, 2005). While there are cross-linguistic differences regarding whether nouns always outnumber verbs in early child spontaneous speech (e.g. Tardif, 1996), in experimental word-learning contexts even children learning languages with pervasive argument ellipsis appear to find it more difficult to learn words for actions than words for objects (e.g. Imai et al., 2008; see also Kim, McGregor, & Thompson, 2000, for naturalistic speech).

There are several possible reasons for this relative difficulty in learning words for actions. One possibility is that young children may be biased to map new words onto objects for which they do not have a name (see Markman, 1994; Markson & Bloom, 1997). This bias may push children to consider novel objects as candidates for the referent of a novel verb. For example, Kersten and Smith (2002) found that three and a half to four-year-old children attended equally to novel objects and their actions when hearing a novel verb describing the object's path or manner of motion. (In fact, a number of studies have found that young preschool children often have difficulty generalising words for actions when other aspects of the original learning event are changed, such as the agent, e.g. Maguire, Hirsh-Pasek, Golinkoff, & Brandone, 2008.) In a particularly strong demonstration, Imai and colleagues (2005, 2008) showed that while three- and five-year-old children were proficient at mapping a novel noun to a novel object, only five-year-olds learned novel verbs appropriately. In these studies, in the Exposure phase for each item children were presented with videos of actors performing novel actions (e.g. twisting an object so that it bends in the middle) on novel objects (e.g. a rubber dog toy shaped like two triangles stuck together). During these videos, children heard a sentence that either used a novel noun (e.g. 'Look! This is a *moop*!') or a novel verb (e.g. 'Look! She is *mooping* it!'). In the Forced-Choice phase for each item, they were asked to find another instance of the novel word (e.g. 'Where is the *moop*?' or 'Where is she *mooping* it?') whereby they had to choose between two scenes: in the Same Action video, the actor performed the same action on a different object, and in the Same Object video, the actor performed a different action on the same object. Although three- and five-year-old children were both able to correctly choose at above chance levels the Same Object video (i.e. the target) on Noun trials, only five-year-old English-speaking children chose the correct Same Action scene (i.e. the target) more often than chance on Verb trials; English-speaking three-year-olds were at chance (Imai et al., 2008). Interestingly, these results were found even for children learning languages with pervasive argument-drop, namely Japanese and Mandarin.

Therefore, Imai et al.'s (2005, 2008) findings suggest that three- (and sometimes five-) year-olds struggle to fast-map onto actions the meanings of novel verbs heard in transitive

sentence frames. This stands in stark contrast to a body of research emerging from the syntactic bootstrapping literature (e.g. Scott & Fisher, 2009). Here, much younger children can fast-map novel verbs onto the correct novel event when asked to choose between two causative events, such as (a) one where a duck is making a bunny rock by pulling its legs versus (b) one where a bunny is spinning a duck around in a chair (e.g. Gertner, Fisher, & Eisengart, 2006; Naigles, 1990; see also Noble, Rowland, & Pine, 2011).

The key difference is that these latter studies did not contain novel objects; 'bunny' and 'duck' are words which are in the receptive vocabularies of one-year-olds and thus can be ruled out as potential referents for the novel verb (Gertner et al., 2006; Naigles, 1990; Noble et al., 2011). However, recently two looking-time habituation studies have found that even around one and a half years children can map novel words to actions and extend these to scenes with the same action but a different novel object during essentially one-trial learning (e.g. Chan et al., 2011; Oshima-Takane, Ariyama, Kobayashi, Katerelos, & Poulin-Dubois, 2011). One crucial difference between the paradigms using the looking-time habituation studies, on the one hand, and the same-novel-action-versus-same-novel-object paradigms used in Imai et al. (2005, 2008) and Kersten and Smith (2002) is that in the habituation paradigm children are never forced to choose between the same object versus the same action on a given trial.

That said, there are two studies by Arunachalam and Waxman (2011, 2015) in which two-year-olds did have to choose between the Same Object versus Same Action video clips on the test trial and indeed by pointing rather than merely via eye-gaze preference. Most crucially for our current purposes, however, in these studies the choice was not between a novel action and a novel object; rather the objects were familiar ones such as 'balloon'. Thus, the children in Arunachalam and Waxman's studies could have simply chosen the same action via mutual exclusivity (e.g. Markman, 1991), or an equivalent process, which is not an option for children tested in the same-novel-action-versus-same-novel-object paradigm. Therefore, overall findings to date suggest that young children have difficulty fast-mapping novel verbs onto novel actions when novel objects are co-present (at least when social-pragmatic cues are removed; cf. Tomasello & Akhtar, 1995, for evidence that 27-month-olds can map correctly when given discourse novelty and/or intention-reading cues).

A second possibility for why verbs are more difficult to learn than nouns is that actions do not always have clear-cut beginning and end points (e.g. Golinkoff & Hirsh-Pasek, 2008; Gentner, 1982), so they may be more difficult to parse from the scene than objects. Transitive verbs in early child language frequently denote causative actions; that is, actions in which one entity (the agent) affects another (the patient) in some way. Many causative actions may involve the agent moving the patient in some manner (e.g. spinning the patient around in a chair or flopping the patient iteratively up and down) but these 'non-resultative' causative actions do not have a clear end point. A number of theorists have argued that prototypical causative actions are 'resultative', that is, they involve a result, typically a change of state (e.g. *wash*) or a change of location (e.g. *hurl*) (e.g. Gropen, Pinker, Hollander, & Goldberg, 1991, p. 162; see also Slobin, 1981). Resultative actions end when the change has been made to the target object, so they may be easier to identify from the scene (see Brandone, Pence, Golinkoff, & Hirsh-Pasek, 2007, for some suggestive evidence in this direction).

Importantly, the actions used by Imai et al. (2005, 2008) were not prototypically causative since they were not resultative because the object did not undergo a change of state or location. Rather, the actions were all of some duration involving iterative non-resultative actions on an object (e.g. the agent repeatedly rolling an object between her palms). As a result, we cannot determine whether children's difficulty in Imai et al.'s (2005, 2008) studies were due to the presence of the novel object, the type of action being taught or a combination of the two.

In addition, there is evidence that children's learning of a new verb is influenced by the timing of the presentation of the new label with respect to the action demonstration. Ambalu, Chiat, and Pring (1997) found that children age 2;3–3;6 years learned novel verbs for non-resultative actions (e.g. spinning an object around) better if the verbs were taught prior to the action. However, for a resultative event (e.g. stamping paper with a printing stamp), the verb was comprehended best when taught on completion of the action. Similarly, Tomasello and Kruger (1992) found that more 24-month-olds were 'comprehenders' (as opposed to non-comprehenders) of a novel verb if it had been taught either prior to or on completion of a resultative novel event in which patients were rolled down a slope into a new location. In contrast, when it had been taught during the action, there were an equal number of comprehenders and non-comprehenders at test. In Imai et al. (2005, 2008), children heard the novel verbs concurrently with the demonstration. Thus teaching and testing a novel verb on completion of the action might improve performance.

The current studies

In two studies, we explored children's learning of action words to determine whether resultative actions are learned better than non-resultative, and whether the timing of the naming differentially impacts the learning of these types of actions (Study 2). For both studies we followed Imai et al. (2008) in that all actions were performed on novel objects, allowing for a strict test of children's verb learning. Our procedure in the Non-Resultative condition closely followed that of Imai et al. (2008), also using novel objects matched to those used by Imai and colleagues (2005, 2008) as listed in Appendix A. The only difference in procedure to Imai et al. (2008) is that we also used the novel verbs in the future tense (e.g. '*She's gonna moop it!*') prior to each action demonstration during the Exposure phase for each novel verb. This was because findings from Tomasello and Kruger (1992) and Ambalu et al. (1997) indicate that hearing a verb prior to an action may be an optimal attention-getter. In our Resultative condition we used punctual actions which either involved a change of location (e.g. head-butting an object onto the floor) or a change of position (e.g. flipping an object over). Punctual actions were chosen because causative actions tend to be expressed by transitive verbs and these tend to refer to punctual actions (e.g. Meints, 1999).

In Study 1 our main research question was whether resultative actions are easier than non-resultative actions. Imai et al. (2008) found (for non-resultative actions) that five-year-old English-speaking children performed above chance when the novel verb was heard in a transitive argument structure (e.g. '*She's blicking it!*) but they performed at chance when the verb was heard in isolation (e.g. '*Look! Blicking!*); whereas

English-speaking three-year-olds were at chance in both conditions with no evidence that this experimental manipulation affected their performance at all. Since Imai et al.'s (2008) five-year-olds were not at ceiling (i.e. they selected the correct Same Action clip 70% of the time), we only tested five-year-olds for Study 1 in our first exploration of the role of Event Type in this paradigm. In Study 2, we maintained our two Event Type conditions (Resultatives vs Non-Resultatives) but also investigated, with both three- and five-year-olds, how the timing of the label affects verb learning.

Study 1

Stimuli verification pre-studies

Prior to running Studies 1 and 2 we also carried out a Salience Control pilot for both Event Types in order to control for whether young children found particular clips more visually salient in some way. For this Salience Control pilot we presented the Forced-Choice component of each experimental item trial (both conditions) and asked 13 three-year-olds '*where is she mooping it?*' without the children having first seen the corresponding Exposure clip. The children pointed at chance indicating that it was not the case that the children would point at the target clips for reasons of visual salience alone. In addition we also showed pictures of all novel objects to seven five-year-olds to ensure that they did not have a name for these objects.

Our first study aimed to determine whether English-speaking five-year-olds would learn novel verbs for resultative actions better than for non-resultative actions.

Design

There were two between-participants Event Type conditions. In the Non-Resultative condition, actions were iterative, durative, non-resultative events replicated from Imai et al. (2005, 2008), such as repeatedly tapping an object against one's thigh (see Appendix A). In the Resultative condition, actions were events in which the object changed location (e.g. agent head-butts object onto floor) or position (e.g. agent flips object over, see Appendix B).

Participants

The children were pre-assigned to one of two between-participants conditions (Resultative vs Non-Resultative). We included 17 five-year-olds in the Non-Resultative (replication) condition (mean age = 63.76 months, range 60–70 months, 47% boys) and 17 five-year-olds in the Resultative condition (mean age = 63.94 months, range 60–69 months, 47% boys). The two groups did not differ in terms of age ($t(32) = 0.16$, $p = .872$, $d = -0.06$). All children were monolingual, typically-developing speakers of British English and we excluded children who scored more than 1 SD below the mean on the Expressive Vocabulary sub-test of the Clinical Evaluation of Language Fundamentals – Preschool (CELF-P, Semel, Wiig, & Secord, 2004). Half in each condition were tested in the Kent Child Development Unit, and half in primary schools in Ashford, Kent (UK). The two

conditions did not differ in CELF-P Expressive Vocabulary raw scores (Non-Resultative $M = 28.65$, range 19–34; Resultative $M = 26.42$, range = 16–34, $t(32) = 1.21$, $p = .24$, $d = 0.42$) whereby the possible maximum raw score was 40). In the Kent Child Development Unit, the parent sat directly behind the child, and in schools each child was tested individually in a quiet area.

Materials

Experimental item materials. As in Imai et al. (2005, 2008), each experimental item trial consisted of an Exposure phase clip followed by a pair of Forced-Choice phase clips. Each Exposure phase clip showed a Caucasian woman carrying out a novel action (Exposure action) with a novel object (Exposure object). The Forced-Choice clips each showed the same actor performing an action on an object. The Target clips were all Same Action in which the agent carried out the Exposure action on a new novel object. The Foil clips were all Same Object, in which the agent carried out a novel action on the Exposure object. Figure 1 illustrates the similarities between the Foil (clip 7) vs Target clips (clip 8) and the Exposure clip (clips 1–6). In the Non-Resultative condition the Exposure actions were durative and iterative and we closely replicated both the actions and objects of the original studies by Imai et al. (2005, 2008) (see Appendix A). In the Resultative condition the Exposure actions were punctual and had a lasting result; for example, the actor carried out an Olympic hammer-throw action in which she twirled an object above her head and then threw it so that it landed on the floor (see Appendix B). The full list of experimental item trial actions and objects for each Forced-Choice phase is listed in the Appendices. For each phase of the experiment, the Resultative and Non-Resultative conditions were matched in length. To accommodate the fact that the resultative actions were of a relatively brief duration, we created non-resultative clips which were equal in length to those in the Non-Resultative conditions and then looped the clips in both conditions. Thus, in the Forced-Choice phase, for example, in both conditions, both the target and foil clips were looped five times (in synchrony) before freezing on the end still clip.

Warm-up phase materials. Each child first participated in a 'warm-up phase' to ensure that children understood that the task was to point to the video clip out of two simultaneously running clips which matched what the Experimenter (E) said. In the warm-up phase, if children pointed to the wrong clip, they received corrective feedback. The warm-up phase was identical for all children and consisted of four trials, always in the same order. In the first warm-up trial, the children saw a clip of a woman eating a banana paired with a clip of a woman cutting a banana and the E asked '*Can you show me: where is she eating it?*' The next trial showed kicking a ball paired with catching a ball and E asked '*Can you show me: where is she catching it?*' Trials 3 and 4 of the warm-up phase were closely modelled on those in Imai et al. (2008), involved novel verbs and were parallel to the experimental item trials with the following key difference: for these warm-up trials, the Target clip of the Forced-Choice phase showed not only the same novel action as the Exposure phase but also the same novel object. Further, for these warm-up novel trials, the foil differed from the Exposure phrase not only in terms of the novel action but also in terms of the novel object. (Thus, even if a child had a bias to map a

novel word to the novel object, he or she should be correct for the novel-verb warm-up trials.) One trial out of warm-up trials 3 and 4 depicted a non-resultative action and the other involved a resultative action.

Procedure

For each trial, a 19 inch touch screen monitor recorded the children's responses, but E also noted down the child's selection. Each child was first administered the four warm-up trials, then the six experimental item trials and finally the CELF-P (Semel et al., 2004). The whole session lasted between 15 and 20 minutes. For the experimental item trials, the procedure is illustrated in Figure 1. Each experimental item trial consisted of two main phases: Exposure (learning), and Forced-Choice.

Exposure phase. Children first saw a still version of the clip (see clip 1, Figure 1) and heard E use the novel verb in a full transitive using the future 'gonna' (e.g. '*She's gonna moop it!*'). E then played the clip, which lasted 3 seconds (clip 2, Figure 1). This was repeated twice (see clips 3–6, Figure 1), and on the third repeat the Exposure video clip was observed for 9 seconds (i.e. looped three times) and E used the same verb in a full transitive in the progressive tense three times (e.g. '*She is mooping it!*'). Thus, in each Exposure phase each child heard the novel verb used in a future tense form of the active transitive three times as well as in the progressive tense.

Forced-Choice phase. In the subsequent Forced-Choice phase, the Target and Foil clips ran simultaneously for 15 seconds (i.e. looped five times) and children were asked '*where is she mooping it?*' The location of the Target clip (left or right side) was counterbalanced both within and across participants, as was the order in which the actions and novel verbs were presented. Children's selection of clip (by pointing and/or vocalising) was recorded.

Data coding

Children scored a point each time they chose the Target clip on the Forced-Choice trials. If a child pointed to both clips, that particular trial was removed from analysis (NA). This occurred for 2% of trials. If a child pointed to one clip but simultaneously said something which clearly indicated that he/she was NOT pointing to respond to the question (e.g. 'not that one'), data were coded according to what he/she said. (This only occurred on one or two occasions.)

Results

In each condition there were six experimental item trials in total. To compare performance to chance, the dependent variable was the proportion of points to the correct (Same Action) clip in the Forced-Choice phase (see Table 1). Participants in the Non-Resultative condition were significantly above chance at pointing correctly ($t(16) = 2.38$, $p < .05$), replicating Imai et al. (2008). In the Resultative condition, children did not point significantly above chance ($t(16) = 1.47$, $p = .16$).

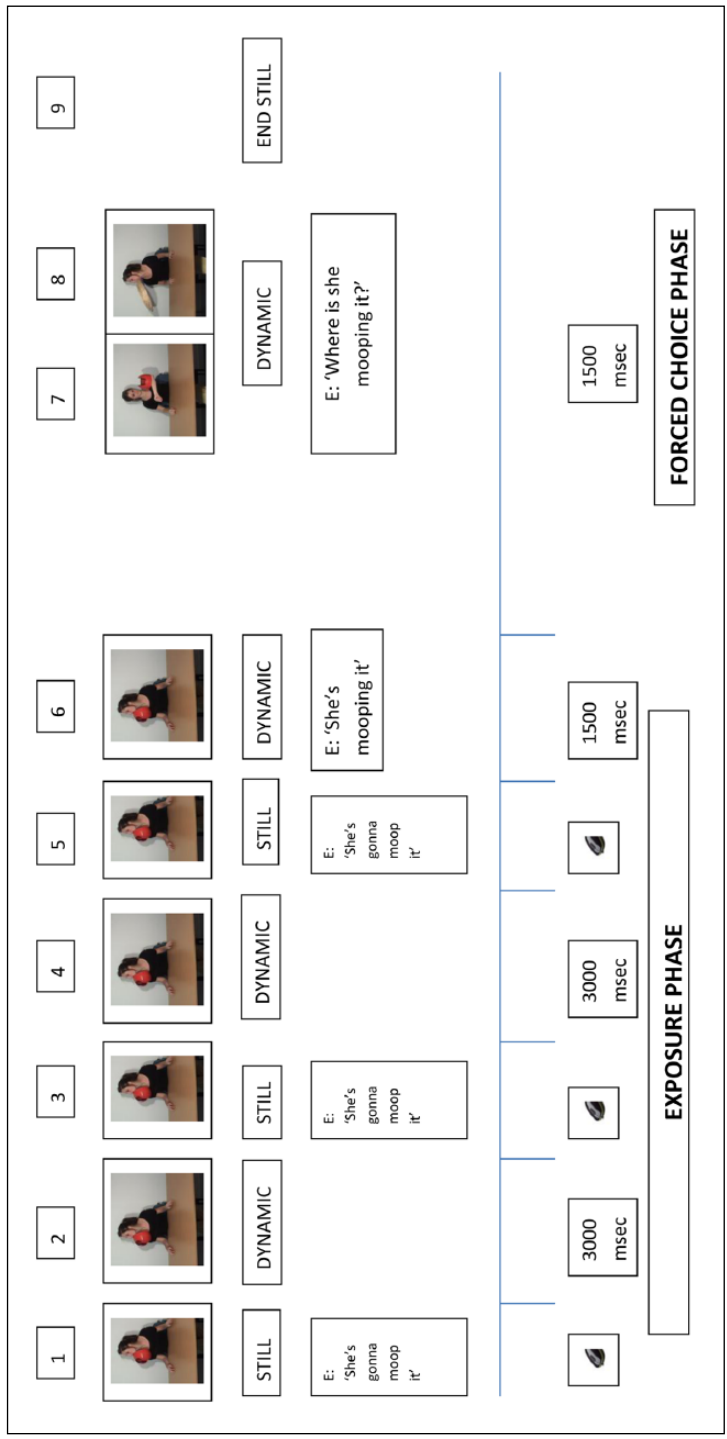

Figure 1. Time course of one representative test trial (time course and timing identical for both Event Type conditions).

Table 1. Mean (SDs) proportion correct points for experimental item trials in Study 1.

Resultative	Non-resultative
.36 (.38)	.69 (.33)

To compare performance across our two experimental conditions, we used a binomial mixed effect model, which treats the dependent variable as a binary choice for each trial. Event Type was treated as a fixed effect and participants were treated as random effects, with random slopes for participants. The *p*-values were computed by comparing models with likelihood-ratio tests and chi-square values are reported. Participants were significantly more likely to correctly identify the Target clip in the Non-Resultative than Resultative condition ($b = 4.65$, SE = 2.03, $\chi^2(1) = 7.33$, $p < .01$). Contrary to our expectations, resultative actions appear to have been more difficult for our five-year-olds to learn than non-resultative actions.

Discussion

We expected that the resultative actions would help children parse the action from the scene, improving performance for resultative over non-resultative actions. However, the reverse was found, with non-resultative actions being better learned. It is possible that participants found the resultative actions more difficult because the visual brevity of punctual actions makes them more difficult to encode. This might be particularly problematic for young children, as their visual processing speed is slower than that of adults (e.g. Liss & Haith, 1970). While motion per se is known to be highly salient for infants who focus on and remember the details of actions such as bubble blowing versus hair brushing (e.g. Bahrick, Gogate, & Ruiz, 2002), this may only be the case for actions of lengthy duration. However, a counterargument to this could be that the key time-point of visual salience for resultatives is once the result (here: location change) is observable, which is after the action has occurred. That is, there may be an interaction between the timing of the linguistic model and the type of event the verb denotes, where durative, non-resultative events are best taught during the event while verbs denoting punctual, change-of-location events are best taught on completion of the event. This view receives some support from previous studies by Tomasello and Kruger (1992), Carr and Johnston (2001) and Ambalu et al. (1997).

Study 2

Study 1 did not provide support for the view that prototypically causative actions will be easier than non-prototypically causative actions to map to novel verbs heard in a transitive sentence frame. To explore the possibility that resultative actions (such as 'flip over' or 'volleyball-underhand-serve') would be learned better if these were taught and tested after the action had occurred, in Study 2 we presented the same stimuli as Study 1, but manipulated the timing (and tense) of the linguistic model. Some children heard the

action descriptor once the action had occurred (in the past tense) and others heard it during the event (in the present tense). We also sought to explore younger children's abilities to learn resultative (such as 'flip over' or 'head-butt-away') versus non-resultative actions (such as 'thigh-tap' or 'palm-roll').

Design and procedure

The design, materials and procedure were identical to Study 1, with the exception that we included three-year-olds and the timing/tense of the verb differed. That is, Age Group (five-year-olds vs three-year-olds), Event Type (Resultative vs Non-Resultative) and Timing (Ongoing vs Past) were fully crossed between-subjects conditions. In the Past condition, the verb was modelled in the past tense after the Exposure clip had stopped (e.g. '*she mooped it*') and the question on the Forced-Choice phases was similarly in the past tense after the clips had stopped (e.g. '*Show me: where did she moop it?*'). The Ongoing conditions were identical to those used in Study 1 (i.e. in each Exposure phase the verb was taught while the action was still ongoing as e.g. '*She is mooping it*' and in the Forced-Choice phases tested as '*Show me: where is she mooping it?*').

Participants

All participants were tested in preschools and primary schools in southern England. As in Study 1, all were monolingual, typically-developing speakers of British English and we excluded children who scored more than 1 SD below the mean on the Expressive Vocabulary sub-test of the CELF-P (Semel et al., 2004). In Table 2 it can be seen that in Study 2 there were four between-subjects conditions for each age group (three-year-olds and five-year-olds). Table 2 also outlines the number of children included in each of these between-subjects conditions for each age group, their mean age in months (and age range), the gender ratio and their mean (and range) CELF Expressive Vocabulary scores.

Results and discussion

One per cent of trials were excluded from analyses because the child pointed to both video clips. As for Study 1, to compare performance across our two experimental conditions, we again used a binomial mixed effect models with effect coded factors (e.g. Baayen, Davidson, & Bates, 2008), whereby the factors were Event Type (Resultative vs Nonresultative), Timing (Ongoing vs Past) and Age (three-year-olds vs five-year-olds). Participants were treated as random effects, with random slopes for participants. The *p*-values were computed by comparing models with likelihood-ratio tests and chi-square values are reported. There was a main effect of Age Group ($b = -4.09$, SE = 0.88, $\chi^2(1) = 24.86$, $p < .001$), showing that the five-year-olds overall were more likely to point at the target (Same Action) clip than were the three-year-olds. There was a main effect of Event Type ($b = -3.87$, SE = 1.36, $\chi^2(1) = 9.47$, $p < .01$), reflecting worse performance on the Resultative conditions than the Non-Resultative conditions. All other main effects and interactions were not significant.

Table 2. Demographics for Study 2.

	Five-year-olds				Three-year-olds			
	Resultative		Non-Resultative (replication)		Resultative		Non-Resultative (replication)	
	Present	Past	Present	Past	Present	Past	Present	Past
Study 2 *M* age	63.84	63.35	63.5	64.33	42.76	43.18	42.65	42.53
Study 2 age range	60–71	60–70	60–69	60–70	36–47	39–47	37–47	40–46
Study 2 % boys	42%	47.8%	45%	19%	47%	47%	47%	47%
Study 2 *M* CELF vocab[a]	25.58	28.17	28.3	29.57	17.88	16.41	15.94	16.88
Study 2 CELF range	16–34	17–37	20–38	22–40	10–25	11–22	10–30	10–22
N	19	23	20	21	17	17	17	17

[a]CELF Expressive Vocabulary possible maximum raw score = 40.

Since we were specifically interested in following up previously established developmental effects, we also carried out binomial mixed effects models for each Age Group separately, with Event Type and Timing fully crossed. For both Age Groups, the only significant effect was for Event Type ($b = -6.07$, SE = 2.70, $\chi^2(1) = 9.33$, $p < .01$ for three-year-olds; $b = -3.44$, SE = 1.40, $\chi^2(1) = 7.65$, $p < .01$ for five-year-olds), whereby both age groups performed worse with the Resultative events. Neither age group showed a significant interaction between Event Type and Timing, nor a main effect for Timing (although the latter showed a trend in the direction of significance for the five-year-olds, $b = -1.69$, SE = 1.03, $\chi^2(1) = 2.90$, $p = .09$).

We also investigated whether the children performed above chance in any of the conditions, whereby the dependent variable was the proportion of target points, conflated over the six experimental item trials. Figure 2 shows the mean proportion of correct responses (i.e. points to the Target clip), by Age Group and condition, with the grey line indicating chance level performance. The only condition in which any age group performed above chance was that of the five-year-olds ($M = 69\%$ correct) with the Non-Resultative events when the novel verb was heard while the action was ongoing (in the present progressive tense) ($t(19) = 2.44$, $p < .05$). Since the original study (Imai et al., 2008) also used present progressive paired with ongoing actions and used non-resultative events, Study 2 (like Study 1) replicated the original results for English-speaking five-year-olds. The three-year-olds pointed significantly *below* chance in all conditions (all $p < .05$), suggesting they interpreted the novel word as relating to the object rather than the action. The five-year-olds only pointed significantly below chance in the condition where they saw resultative events and were taught and tested on the novel verb after the action was completed ($t(22) = 2.73$, $p < .05$), which ran precisely counter to our prediction that this would be the condition in which children performed best. Verb meanings were not learned more easily when they were taught on completion of the action, for any Age Group or Event Type. Three-year-olds and even five-year-olds in certain contexts appear willing to map a novel verb heard in an active transitive (e.g. 'She's mooping it') onto a novel object.

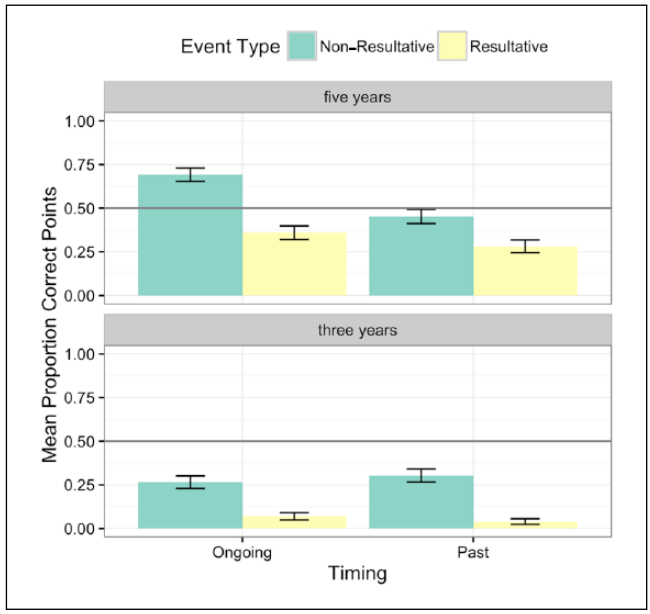

Figure 2. Mean proportion of correct points for Study 2, by Event Type, Age Group and Timing Condition.

General discussion

We carried out two studies to replicate and extend Imai et al.'s (2005, 2008) paradigm, which pits novel objects versus novel actions as potential referents for novel verb learning. In line with Imai et al. (2005, 2008) we found that five-year-olds were able to choose the correct clip (i.e. blicking = action) for the Non-Resultative Event Type (e.g. iterative 'rolling-between-palms' or 'fencing-stabs', see Appendix A). Over both studies, children found the resultative events (e.g. 'flipping over' or 'head-butting-away', see Appendix B) more difficult than the original non-resultative events. In Study 2 we found that hearing the new verb in the past tense (e.g. *blicked*) after the action was complete did not have the predicted ameliorating effect on how successfully either five- or three-year-olds mapped the new verb for resultative events.

Our findings from Study 2 do not fit with previous findings (e.g. Ambalu et al., 1997; Carr & Johnston, 2001; Tomasello & Kruger, 1992) which had suggested that teaching verbs on completion of the action would lead to better performance with resultative event types than teaching verbs while the action is still ongoing. To the contrary, both age groups performed poorly in our past conditions; the difference between the past and ongoing conditions was of marginal significance for the five-year-olds. However, it is possible that if we had used change-of-state actions, we would have found the predicted interaction between tense and event type. That said, there is no evidence that change-of-state events are more prototypically causative than the change-of-location events that we used; the evidence that exists, although sparse, appears to suggest that both are in fact

prototypically causative as long as the action is intentionally caused (e.g. Muentener & Lakusta, 2011). Moreover, there are a limited number of *novel* ways in which a state can change (i.e. so that a preschooler would not simply describe the event as *break, clean, colour, cover, fix* or *open/shut*) and once a novel object has changed state, it is then not the same object as it was initially, which might be problematic for the Same Object foil used in the original studies (e.g. Imai et al., 2005, 2008). Furthermore, Tomasello and Kruger (1992) used a resultative action involving a punctual, change of location and this was learnt better when taught on completion of the action than when taught while the action was still ongoing.

While we clearly replicated Imai et al.'s (2008) findings for English-speaking five-year-olds, this is less clear for the three-year-old groups, who performed significantly below chance even in the replication condition (resultatives with ongoing action), indicating that they were mapping the novel verb in '*She is blicking it*' onto the novel object. The English-speaking three-year-olds in Imai et al.'s (2008) study pointed to the target (Same Action) clip 42% of the time, which was not significantly below chance. That said, with the same stimuli Imai et al. (2008) found that three-year-olds had very low performance; Japanese-speaking three-year-olds were correct 39% of the time in the Verb condition. For Mandarin-speaking children, even five-year-olds were only correct 17% of the time in the Verb condition, which was significantly below chance.

Therefore, our findings clearly line up with those of Imai et al. (2008) and also Kersten and Smith (2002) to indicate that three-year-olds will, when given a choice between a novel action and a novel object, frequently assume that the novel word refers to the novel object. The forced choice between a novel object and a novel action is particularly difficult because it is a true 'Quinean' (Quine, 1960) scenario and because objects appear to have much greater salience than the Same Action (e.g. Gentner, 1982, 2006; Kim et al., 2000; Markman, 1991), presumably due to factors such as temporal permanence, greater concreteness, individuation and imageability (e.g. Golinkoff & Hirsh-Pasek, 2008; McDonough, Song, Hirsh-Pasek, Golinkoff, & Lannon, 2011).

We cannot, however, determine exactly why the presence of a novel object makes the process of fast-mapping novel verbs to novel actions more difficult for young children. While it could be that children have a bias to map novel words onto whole objects (e.g. Markman, 1991), it is also possible that the pattern of results could be at least partially due to the difficulties which three-year-olds face with response inhibition (e.g. Beck, Schaefer, Pang, & Carlson, 2011). That is, the greater concreteness, individuation and temporal permanence of objects may attract children's attention, lead to a greater depth of encoding in memory and thus when presented with a forced choice, they find it difficult to inhibit the inclination to select the novel object. Future studies could potentially attempt to disentangle these possibilities by investigating whether performance in this paradigm correlates with measures of inhibitory control (see e.g. Krott & Snape, 2015, for this type of relationship for a different word learning paradigm). Whatever the underlying reason, the predominant factor may be that of relative visual salience of particular items. We used change-of-location actions which are frequently punctual events. These might in fact be particularly difficult to fast-map new verbs onto simply because their temporal brevity makes their details (at least of manner of motion) more difficult to encode in memory than durative actions. Interestingly, punctual, change-of-location

verbs such as *drop, throw, dump, knock over* are among the first handful of verbs which young English-speaking children learn (e.g. Fenson et al., 1994; Just, Christopher, Meints, Rowland, & Alcock, 2015). However, the addition of discourse and other socio-cognitive cues, such as cues allowing intention-reading, appears to allow even very young two-year-olds to map novel punctual, change-of-location causative actions onto novel words in the presence of novel objects (Tomasello & Akhtar, 1995; see also Hohenstein, 2013, for a constructivist account of how parent–child interaction scaffolds the acquisition of motion verb semantics).

In sum, it appears that basic perceptual components of actions play a predominant role in the fast-mapping phase of the acquisition of verb meaning. While a role for perceptual salience is built in certain theories of word learning such as the Emergentist Coalition Model (e.g. Golinkoff & Hirsh-Pasek, 2008), what this theory does not predict is that perceptual salience continues to play such a predominant role at three and five years that it overrides morpho-syntactic cues. (Notably in the current study, the novel verbs were heard in an active transitive frame 'SUBJECT is VERBing OBJECT' with a case-marked subject.) Therefore, in the absence of socio-cognitive cues (e.g. Tomasello & Akhtar, 1995) objects do appear to be more visually salient than actions and this perceptual salience appears to swamp the syntactic knowledge of three-year-olds when visual perceptual salience and morpho-syntax are pitted against one another.

Conclusion

Our findings fit with a large body of evidence that young children find it easier to learn new words for objects than for actions (e.g. Childers & Tomasello, 2002, 2006; Gentner, 2006). In the absence of social-cognitive cues, three- and sometimes even five-year-olds appear influenced by visual perceptual salience factors to a greater degree than by prototypical causality when fast-mapping novel verbs. This may lead them to frequently (initially) mistakenly fast-map novel verbs onto novel objects, because objects are more salient than actions, and it also may lead them to have more difficulty mapping those actions which are of temporal brevity. Since children must learn a large number of punctual verbs, our results elucidate something of the nature of the complexity of the task which children face when they hear new verbs for the very first time.

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Appendix A. Description of actions and objects for non-resultative (replication) condition.

Target action	Same Action	Same Object
Palm-roll	Action: *palm roll* (roll object between palms of hands) Object: has long handle and bulb-like piece on end	Action = *repeatedly lightly toss and catch* Object = American-football-shaped object with coloured stripes and purple 'feet' parts
Dry-back	Action: *back-dry* (hold object behind back & pull it up and down as if drying your back) Object: long, narrow meshed grey twisty object	Action: *Torso-twist* (Holds object in front of self, with a hand at each end, and twist torso from side to side). Object: A long, blue, plastic arch-shaped ball-thrower for dogs.
Punch-outwards	Action: *crucifix-defence* (hold object in right hand and push it outward as if holding a crucifix to ward off a vampire) Object: a round metallic timer	Action: *Shoulder-tap* (Holds object in right hand and taps against left shoulder). Object: A black plastic angular drainpipe part with red stripes.
Wring-out	Action: *wring out* (hold object in both hands at chest level, twisting it so that it bends in the middle, as if wringing out a wet cloth) Object: a large circular blue rubber ring	Action: *Flop up and down* (Holds object in right hand and slightly move that hand so that the object flops up and down). Object: A large red rubber dog toy consisting of two loops.
Fencing-pronation-tierce	Action: *repeated fencing-stabs* (hold object in right hand, pushing it out with a stabbing motion) Object: a long wire cylindrical CD rack	Action: *Knee-tap* (Holds object in right hand and tap against her right knee, which she raises at the same time as she is lowering the object). Object: A bamboo candle holder on a long thin stem.
Thigh-tap	Action: *thigh-tap* (tap against thigh) Object: a large black curved pipe	Action: *Finger-roll* (Hold object with the index fingers of each hand stuck into the hole in the centre and roll the object around fingers). Object: A round wooden toy with holes in the top for shapes to be put into.

Appendix B. Description of actions and objects for resultative condition.

Target action	Same Action	Same Object
Flip-over	Action: *flip over* (put hand on edge of object and flip it over so that it lands upside-down on the other side of the table) Object: large, blue, round, plastic object with legs	Action: *Finger-twirl-and-toss* (twirls object around index finger so that it flies off). Object: Small, round object made of metal with criss-crossing parts across the radius and a green plastic rim with green fins.
Foot-drop	Action: *foot-drop* (balance object on foot and then withdraw foot so that object drops) Object: a blue plastic bulb with a yellow base and round white plate on top	Action: *Bullwinkle-antler-set* (balance object on the fingertips of both hands and then tosses it up into the air like a Bullwinkle-antler set in volleyball). Object: A large light blue plastic square object.
Dog-throw	Action: *dog-mouth-throw* (hold object in mouth and then throw by tossing head) Object: a large round wicker clothes basket lid	Action: *Elbow-jerk* (balance on elbow and then toss upwards by jerking elbow). Object: A red round plastic half of a swing-top dustbin lid.
Underhand-serve	Action: *volleyball-underhand-serve* (balance object on fist and bring other fist underneath the first in a punching motion) Object: solid metal cylindrical object decorated with red flowery bows	Action: *Finger-flick* (prototypical interpretation of flick) Object: A wooden rectangular object with three round holes in the side and a red handle.
Hammer-throw	Action: *Olympic hammer-throw* (swirl once around head and then throw like an Olympic hammer-thrower) Object: metal toilet roll stand with spiral-shaped metal base and covered in red ribbons	Action: *Upwards-wrist-flick* (Hold object between index fingers and thumbs by both hands and flick it up into the air). Object: Blue plastic oblong object with two cross-pieces.
Head-butt	Action: *head-butt* (hold object in both hands and head-butt it onto the table) Object: a red, yellow, blue and green striped kite rolled up so that it is long and thin but with streamers hanging off it	Action: *Elbow* (Elbow object so that it topples over). Object: A stacking ring with white plastic base and yellow plastic stem.