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Learning the Causative Alternation in English and Japanese Speakers: Statistical and Non-statistical Effects

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ABSTRACT

Children acquire argument structure through distributional evidence, but how does this interacts with event semantics and existing verb knowledge? The current study compares verb learning in adult speakers of Japanese (where lexical causatives span wider semantic categories) and English (where alternation is more restricted). In the Fully alternating familiarization, internally caused events (similar to *descend*) and externally caused events (similar to *rock*) occurred with novel verbs in transitive and intransitive frames. In the Semi-alternating familiarization, internally caused events occurred with intransitives only while externally caused events occurred with both frames. During the test, participants rated the naturalness of transitive and intransitive descriptions for all events. For internally caused events, transitives were rated equivalently low across speakers after the Semi-alternating familiarization (which featured only intransitives), while intransitives were more felicitous for English compared to Japanese speakers. For externally caused events, all participants rated transitives higher than intransitives, despite equal occurrence across familiarizations. This may be related to the presence of salient animate agents in scenes. Together, this suggests that syntactic and semantic biases concurrently influence the interpretation of distributional evidence. Input statistics are interpreted through existing syntactic representations, and salient semantic distinctions may exert a bias for syntactic instantiations.

Introduction

Verb learning involves mapping form to meaning, but scenes are often consistent with multiple meanings, while meanings are consistent with some-but-not-all forms. Across verbs, transitive frames highlight external agents (e.g., *She killed the spider*), and intransitive frames highlight outcomes (e.g., *The spider died*). Yet, individual verbs are idiosyncratic, and children must avoid overgeneralizing frames to restricted verbs (e.g., **She died the spider*). To do so, they can exploit form-to-meaning relationships in two directions. First, knowledge of event semantics can inform suitable frames (Levin & Rappaport Hovav, 1995; Pinker, 1989). Externally caused events are often encoded with alternating verbs (e.g., *The cradle rocks → She rocks the cradle*), while internally caused events are often felicitous in intransitives but not transitives (e.g., *She laughs → *She laughs the child*). Consistent with this pattern, 5-year-olds reveal an intransitive preference for self-caused events (e.g., *laugh*) but adopt either frame for events with optional external causes (e.g., *fall*) (Ambridge, Pine, Rowland, & Young, 2008). Second, knowledge of syntactic distributions isolates meanings within scenes (Fisher, 1996; Gleitman, 1990). Learners as young as 2 years map transitive frames to externally caused events (e.g., *He's gorping him* implies pushing another boy) and intransitive frames to internally caused events (e.g., *He's gorping* implies swinging his own arm) (Naigles, 1990; Yuan & Fisher, 2009).

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However, it remains less clear where syntactic and semantics biases come from and how they interact in acquisition. Children recruit distributional patterns to isolate argument structure (Ambridge, Pine, & Rowland, 2012; Qi, Yuan, & Fisher, 2011; Wonnacott, 2011), but language learning involves inferring representations that generate evidence rather than simply mimicking input statistics. As such, expectations about form-to-meaning mapping may influence how learners interpret distributional patterns. Relatedly, syntactic and semantic bootstrapping are sometimes pitted as mutually exclusive approaches to verb learning (Fisher, 1996; Pinker, 1984), a viewpoint reinforced by experiments that vary syntactic distributions while holding event semantics constant (Naigles, 1990; Qi et al., 2011; Yuan & Fisher, 2009). Nevertheless, real-world environments provide both sources of information, which may be useful across different contexts. When children can identify how syntactic regularities isolate verb meanings, they may rely on these highly reliable cues. Yet, when this knowledge is limited earlier in development or in underinformative contexts (e.g., noisy speech), children may lean on expectations that semantic distinctions will be instantiated syntactically in their language.

Prior research illustrates the effects of semantic and syntactic biases when interpreting verb statistics. First, languages lexicalize verbs differently (Talmy, 1985). For example, English focuses on manner of motion (e.g., *run*), while Spanish and Greek focus on path (e.g., *descend*). Across adults and children, language-specific preferences influence novel-verb interpretations (Maguire et al., 2010; Naigles & Terrazas, 1998; Papafragou, Massey, & Gleitman, 2002; Papafragou & Selimis, 2010) by reducing sensitivity to scene-sentence statistics that conflict with native distinctions (Kersten et al., 2010; Shafto, Havasi, & Snedeker, 2014). Likewise, studies of artificial languages demonstrate that syntactic biases of existing verbs influence interpretation of new verbs (Wonnacott, Newport, & Tanenhaus, 2008). In a generalist language, a frequent frame (VPA: verb-patient-agent) occurs more often than an infrequent frame (VAP: verb-agent-patient) for all eight verbs. In contrast, in a lexicalist language, the frequent (VPA) frame occurs exclusively with seven verbs and the infrequent (VAP) frame with one verb only. While base rates of frames were identical in both languages (VPA is 7x more frequent than VAP), adult learners of a generalist language extend a frequent structure to new verbs and ignore evidence of an infrequent structure more than learners of a lexicalist language (see Wonnacott (2011) for related patterns in children's learning of noun particles). Together, this demonstrates that language-specific knowledge influences how learners attend to distributional patterns in the input.

While past research isolates syntactic and semantic biases, the current study examines concurrent interactions by comparing verb learning in adult speakers of English and Japanese. External causes of events are productively highlighted using a periphrastic construction in English (e.g., *She made him laugh*) or a causative morpheme in Japanese (e.g., Hanako-nom Taro-acc go-*ase*-past → *Hanako made Taro go*) (Shibatani, 1976). Importantly, both languages also feature lexical causatives that alternate between transitives and intransitives (Haspelmath, 1993), see (1). These verbs adopt similar forms in English and stems in Japanese across frames (e.g., *yur-asu* [transitive] vs. *yur-eru* [intransitive]), and often describe events with external causes, such as manner of motion (e.g., *rock*) and change of state (e.g., *turn*) (Croft, 1991; Shibatani & Pardeshi, 2002). However, the two languages differ in how they treat events with internal causes. In English, verbs of directed motion (e.g., *descend*) and disappearance (e.g., *vanish*) only occur in intransitives (Levin & Rappaport Hovav, 1995; Pinker, 1989) while in Japanese, these verbs alternate between frames (Jacobsen, 1992; Nagano, 2015), see (2).

(1)	a. Transitive.	Japanese:	Kanojo-ga yurikago-o yurasu She-nom cradle-acc rock
		English:	She rocks the cradle.
	b. Intransitive.	Japanese:	Yurikago-ga yureru Cradle-nom rock
		English:	The cradle rocks

(2) a. Transitive. Japanese: Kanojo-ga hikouki-o sageru
She-nom plane-acc descend
English: *She descends the plane.

b. Intransitive. Japanese: Hikouki-ga sagaru
Plane-nom descend
English: The plane descends.

To examine how event semantics and syntactic restrictions affect the interpretation of distributional statistics, we created two learning contexts (Figure 1). In the Semi-alternating familiarization, participants saw novel verbs for externally caused events alternated between transitives and intransitives (akin to *rock, turn, break*), while verbs for internally caused events occurred in intransitives only (akin to *vanish, descend, die)*. In the Fully alternating familiarization, participants saw all verbs alternated between frames. During the test, everyone was presented with new scenes for events and rated the naturalness of transitive and intransitive sentences. If syntactic preferences are sensitive to

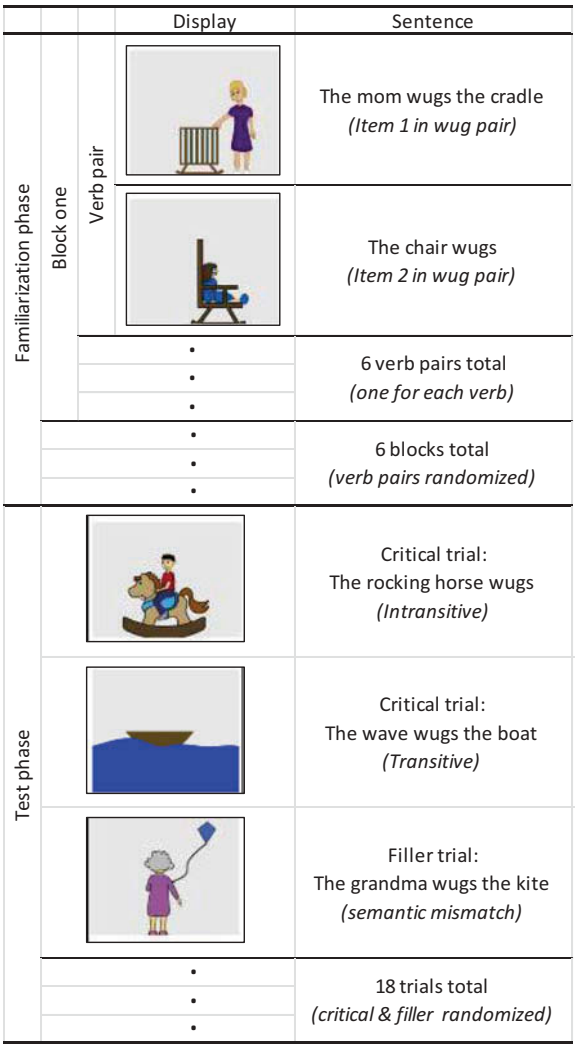

Figure 1. Sequences of sample trials within familiarization and test phases.

distributional patterns, then internally caused verbs should favor intransitives after the Semi-alternating familiarization but equivocate after the Fully alternating familiarization. Importantly, if syntactic and semantic biases also influence inferences about argument structure, then divergences from input statistics may emerge. After the Semi-alternating familiarization, Japanese speakers may adopt a weaker intransitive preference compared to English speakers since existing internally caused verbs often alternate.

Methods

Subjects

Fifty-nine native English-speaking undergraduates from the University of Maryland College Park and 60 native Japanese-speaking undergraduates from Kanagawa University were randomly assigned to a familiarization. After testing, data from three English speakers and six Japanese speakers were excluded because they used the same rating for all trials. This resulted in a final sample of 56 English speakers (28 in the Semi-alternating familiarization, 28 in the Fully alternating) and 54 Japanese speakers (29 in the Semi-alternating familiarization, 25 in the Fully alternating). No English speaker had experience with Japanese, but Japanese speakers all reported English exposure through school curricula. Test of English for International Communication confirmed basic communicative abilities (e.g., asking and answering questions about employment, shopping, family). However, follow-up analyses revealed no relationships between participants' scores and performance on the current task (p's > .60).

Materials and procedures

Critical conditions were based on a 2 x 2 × 2 × 2 design. Between-subjects factors contrasted (1) native speakers of a language with greater semantic restrictions on lexical causatives (English) vs. one that imposes fewer (Japanese), and (2) novel-verb familiarization that semantically restricts causatives (Semi-alternating) vs. one that does not (Fully alternating). Within-subjects factors contrasted (1) events with external vs. internal causes, and (2) judgments of transitive vs. intransitive frames. Transitive frames always featured agents as subjects and patients as objects, while intransitive frames always featured patients as subjects. Sentence frames were always written in participants' native language.

Participants were told that this was a language-learning task involving two parts (Figure 1). First, during the familiarization phase, they saw animated events and written sentences and were asked to remember how sentences related to events. Novel verbs occurred with two unique scene-sentence combinations, and distributional patterns varied with event and familiarization type (Table 1). In Semi- and Fully alternating familiarizations, externally caused events involved manner of motion (ROCK: *wug-yachi*, TURN: *dak-chimo*) and change of state (BREAK: *glorp-ruchi*) and always occurred with a transitive and intransitive sentence. This is similar to lexical causatives in English and Japanese. In the Semi-alternating familiarization, internally caused events involved directed motion (DESCEND: *torg-heku*) and disappearance (VANISH: *kurp-nuhe*, DIE: *prud-kanu*) and occurred with two intransitives. This is similar to causatives in English. In the Fully alternating familiarization, all events were paired with a transitive and intransitive sentence, similar to Japanese. To draw attention to distributional patterns, scene-sentence combinations were presented consecutively for each verb. However, the order of frames within verbs and event types across verbs were randomized. To ensure sufficient experience, participants received six exposure blocks, which yielded a total of 72 scene-sentence presentations (2 frames x 6 verbs x 6 blocks). The order of verb presentation was randomized across blocks.

During the test phase, participants saw events from the familiarization phase paired with new agents and patients. They were asked to rate how sentences described scenes on a scale of 1 (very poorly) to 7 (very well). Six verbs occurred with matching events (e.g., ROCK: *wug-yachi* with a boy rocking a rocking horse) in transitives and intransitives to yield 12 critical trials. The order of verb-sentence combinations was randomized. To ensure that participants learned correct verb meanings, critical trials

Table 1. Sample novel verbs and syntactic frames in (A) Familiarization and (B) Test phases. Participants received either Semi-alternating or Fully alternating patterns during familiarization but rated all verb-frame combinations during the test.

	SEMI-ALTERNATING		FULLY ALTERNATING	
(A) Familiarization phase				
Externally caused events (e.g., *wug* or *yachi* = rock)	TRANSITIVE	English: The mom wugs the cradle. Japanese: Okasan-ga yurikago-o yachi. *Mother-NOM cradle-ACC yachi.*	TRANSITIVE	English: The mom wugs the cradle. Japanese: Okasan-ga yurikago-o yachi. *Mother-NOM cradle-ACC yachi.*
	INTRANSITIVE	English: The chair wugs. Japanese: Isu-ga yachi. *Chair-NOM yachi.*	INTRANSITIVE	English: The chair wugs. Japanese: Isu-ga yachi. *Chair-NOM yachi.*
Internally caused events (e.g., *torg* or *heku* = descend)	INTRANSITIVE	English: The car torgs. Japanese: Kuruma-ga heku. *Car-NOM heku.*	TRANSITIVE	English: The man torgs the car. Japanese: Otoko-ga kuruma-o heku. *Man-NOM car-ACC heku.*
	INTRANSITIVE	English: The airplane torgs. Japanese: Hikouki-ga heku. *Airplane-NOM heku.*	INTRANSITIVE	English: The airplane torgs. Japanese: Hikouki-ga heku. *Airplane-NOM heku.*
(B) Test phase				
Externally caused events (e.g., *wug* or *yachi* = rock)	INTRANSITIVE	English: The rocking horse wugs. Japanese: Uma-ga yachi. *Horse-NOM yachi.*	TRANSITIVE	English: The wave wugs the boat. Japanese: Nami-ga booto-o yachi. *Wave-NOM boat-ACC yachi.*
Internally caused events (e.g., *torg* or *heku* = descend)	INTRANSITIVE	English: The elevator torgs. Japanese: Erebeta-ga heku.	TRANSITIVE	English: The captain torgs the submarine. Japanese: Kyaputen-ga sensuikan-o heku.

Table 2. Descriptive statistics for sentence rating for by native language, familiarization, event type, verb item, and sentence frame.

				English speakers		Japanese speakers	
				M	SD	M	SD
Semi-alternating	Externally caused	Break	Intransitive	4.6	2.3	3.6	2.6
			Transitive	4.3	2.5	3.1	2.4
		Rock	Intransitive	4.6	2.5	3.8	2.7
			Transitive	5.3	2.3	3.9	2.6
		Turn	Intransitive	4.7	2.2	3.2	2.3
			Transitive	4.6	2.6	4.0	2.7
	Internally caused	Descend	Intransitive	4.8	2.2	3.5	2.6
			Transitive	3.2	2.3	3.5	2.5
		Vanish	Intransitive	4.3	2.5	4.0	2.5
			Transitive	2.4	1.9	3.5	2.7
		Die	Intransitive	5.1	2.2	4.2	2.6
			Transitive	3.2	2.2	3.8	2.3
Fully alternating	Externally caused	Break	Intransitive	4.4	2.5	2.7	2.3
			Transitive	4.6	2.6	3.6	2.3
		Rock	Intransitive	5.1	2.3	3.5	2.5
			Transitive	5.0	2.5	3.9	2.7
		Turn	Intransitive	4.7	2.2	3.1	2.5
			Transitive	4.6	2.2	3.6	2.5
	Internally caused	Descend	Intransitive	4.4	2.3	3.4	2.5
			Transitive	4.1	2.5	3.4	2.6
		Vanish	Intransitive	4.2	2.2	3.2	2.4
			Transitive	3.9	1.9	3.9	2.4
		Die	Intransitive	4.6	2.2	4.4	2.3
			Transitive	4.8	2.4	3.9	2.5

were randomized with six additional filler trials that paired sentences with semantically mismatching scenes (e.g., ROCK: *wug-yachi* with a grandmother flying a kite). Half occurred in transitives, and half in intransitives, but all were expected to yield low ratings. To ensure that visual properties did not drive syntactic preferences, all scenes in the familiarization and test phases were paired with transitives and intransitives (e.g., a woman rocking a cradle described as *The mother wugs the cradle* and *The cradle wugs*). These combinations were counterbalanced over four presentation lists. Within a list, each participant saw only one scene paired with either a transitive or intransitive sentence.[1]

Results

Sentence ratings were analyzed through linear mixed-effects models, using the lme4 software package in R (Bates, Maechler, Bolker, & Walker, 2015). Maximal models included random slopes and intercepts for subjects and items, but simpler models were adopted with random intercepts only when maximal models failed to converge (Barr, Levy, Scheepers, & Tily, 2013). Parameter-specific *p*-values were estimated through Satterthwaite approximation (Luke, 2017). Table 2 provides descriptive statistics for item-level ratings in critical trials.

To confirm the learning of verb meanings, we analyzed ratings based on native language and trial type. As expected, sentences were more felicitous when matching compared to mismatching scenes ($t = 19.20$, $p < .001$). English speakers produced higher ratings compared to Japanese speakers ($t = 3.13$, $p < .01$), but this difference interacted with a trial type ($t = 4.47$, $p < .001$). Participants rated filler trials similarly poor ($t = 1.15$, $p > .20$), but English speakers considered critical trials more felicitous compared to Japanese speakers ($t = 2.78$, $p < .05$).[2] To understand how syntactic preferences (sentence

[1]The materials, data, and analysis code can be found at https://osf.io/jy2az/.

[2]Since we also counterbalanced filler trials across lists, three out of 12 item combinations involved mismatching scenes paired with ungrammatical sentences. These trials yielded lower rating compared to mismatching scenes with grammatical sentences (1.9 vs. 2.5, $p < .05$), suggesting that participants used the full scale to convey a verb's syntactic and semantic fit.

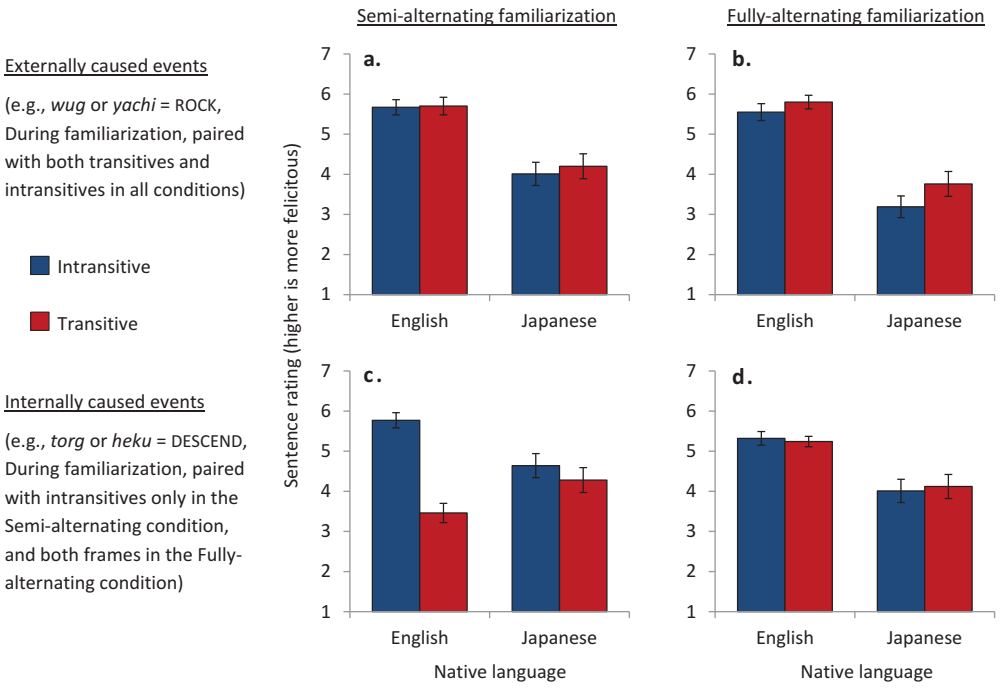

Figure 2. Sentence rating by native language for externally caused events in (a) Semi-alternating and (b) Fully alternating familiarizations, and internally caused events in (c) Semi-alternating and (d) Fully alternating familiarizations.

frame) arise from interactions between current statistics (familiarization) and past experience (native language, event type), we focused on critical-trial ratings. This revealed a four-way interaction ($t = 2.13$, $p < .05$). To unpack this pattern, we separated trials by event type and assessed the effects of native language, familiarization and sentence frame.

Externally caused events

In Figure 2a,b, English speakers rated externally caused events higher than Japanese speakers, leading to a main effect of native language ($t = 5.49$, $p < .001$). Moreover, transitives were rated higher compared to intransitives ($t = 2.32$, $p < .05$). These differences are unexpected since externally caused events occurred in identical distributions across speakers and familiarizations. We will return to this in the Discussion. Additional effects and interactions between native language, familiarization and sentence frame were not significant (p's $> .15$).

Internally caused events

In Figure 2c,d, ratings for internally caused events were higher for intransitives compared to transitives ($t = 5.06$, $p < .001$). Importantly, this difference was qualified by two-way interactions between native language and sentence frame ($t = 4.10$, $p < .001$) and frame and familiarization ($t = 5.30$, $p < .001$) as well as a three-way interaction between native language, frame and familiarization ($t = 3.39$, $p < .001$). To understand these interactions, we separated trials by familiarization and isolated effects of native language on syntactic preferences. In the Fully alternating familiarization, English speakers rated internally caused events higher than Japanese speakers, leading to a main effect of native language ($t = 2.21$, $p < .05$). There was no additional effect or interaction with sentence frame (p's $> .60$).

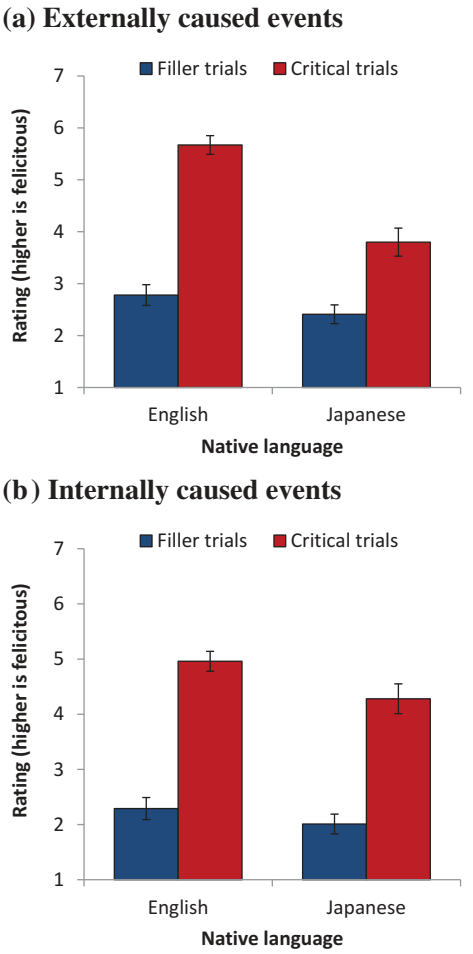

Figure 3. Sentence rating by native language and trial type for (a) Externally caused events and (b) Internally caused events.

In the Semi-alternating familiarization, however, intransitives were more felicitous than transitives (t = 6.25, p < .01), but syntactic preference varied with native language (t = 3.79, p < .05). To unpack this two-way interaction, we separated trials based on frame and compared effects of native language. Transitives never occurred during familiarization, and participants rated this frame equivalently low (t = 1.42, p > .15). However, intransitives were present during familiarization, and English speaker rated them more felicitous compared to Japanese speakers (t = 2.04, p < .05). This suggests that current distributional statistics were assessed based on learners' existing syntactic biases. Additional effects and interactions between native language, familiarization and sentence frame were not significant (p's > .90).

Were internally caused verbs harder to learn?

However, it is possible that Japanese speakers' dispreference for intransitive descriptions of internally caused events reflected general difficulties with learning specific verb types, rather than effects of past experience on current statistics. If this were true, it may also limit their ability to distinguish correct meanings of internally caused events in critical trials from incorrect meanings in filler trials. To assess this, we analyzed ratings based on native language, trial type and event type. Consistent with prior

patterns, we found two-way interactions between the native language and trial type ($t = 2.47$, $p < .05$) and native language and event type ($t = 3.24$, $p < .01$). However, these were qualified by a three-way interaction between native language, trial type and event ($t = 3.42$, $p < .001$). In Figure 3a,b, the meanings of externally caused events were differentiated to a greater extent by English compared to Japanese speakers ($t = 3.54$, $p < .001$), suggesting possible cross-linguistic effects on learning these verbs. We will return to this a point in the Discussion. Importantly, there was no interaction between the native language and trial type for internally caused events ($t = 0.65$, $p > .50$), suggesting that these meanings were mastered to the same degree. Thus, decreased sensitivity to the distributional patterns of internally caused verbs is unlikely to reflect inadequate learning among Japanese speakers.

Discussion

The current study examined the role of syntactic and semantic biases when learning verb argument structure. Consistent with current statistics, participants adopted a stronger intransitive preference when internally caused verbs occurred in intransitives only compared to when they alternated between frames. Importantly, syntactic judgments were also influenced by past experience with known verbs. Since English imposes greater semantic restrictions on syntactic alternations compared to Japanese, English speakers readily adopted a preference when intransitives occurred with internally caused verbs. In contrast, Japanese speakers were less likely to assume that the absence of transitives limited verb alternation. While effects of prior knowledge on statistical learning have been found in artificial-language paradigms (Wonnacott, 2011; Wonnacott et al., 2008), this study is the first to establish analogous patterns among learners of natural languages. Together, this suggests that existing knowledge may serve as a filter for interpreting new evidence, such that learners rapidly assimilate regularities that exist in their language and discount data that do not conform to dominant patterns.

There were, however, two aspects of our findings that were unexpected. First, all participants exhibited a transitive preference for externally caused events (e.g., ROCK, BREAK, TURN). This is puzzling since these events occurred with alternating frames both in the current study and across native languages. Second, English speakers were more likely to consider all descriptions of externally caused events to be felicitous. Closer inspection of these scenes revealed a wealth of salient animate agents (e.g., man turning a plate, woman turning a wheel), i.e., all six items during the familiarization phase, five items during the test phase. Animate agents were rarely present for internally caused events (i.e., 1 out of 12 items), which featured hidden (e.g., pilot landing a plane) or inanimate agents instead (e.g., fog covering a building). While current explanations are admittedly speculative, it is possible that syntactic judgments were influenced by non-linguistic expectations about whether animate agents should be linguistically mentioned. This semantic bias may lead to an overall transitive preference for externally caused events among all participants. Moreover, for English speakers, this bias may interact with a language-specific expectation that lexical causatives are conditioned on event semantics. Thus, semantic cues to external events (e.g., salient animate agents) may provide a stronger basis for adopting alternating frames than for Japanese speakers. While more work is needed to test this hypothesis, it is consistent with cross-linguistic differences in verb lexicalization (e.g., manner-path distinction, Maguire et al., 2010; Naigles & Terrazas, 1998; Papafragou et al., 2002; Papafragou & Selimis, 2010) and recent work demonstrating that children's transitive preferences in English are shaped by non-linguistic cues to causal events (Kline, Snedeker, & Schulz, 2017).

A potential concern is that participants' judgments were based on direct translations to known verbs rather than their current statistical experience. On the face of things, this could explain cross-linguistic effects for internally caused verbs. If Japanese speakers translated *heku* to *descend*, this would lead to a weaker intransitive preference compared to English speakers. Nevertheless, this strategy requires participants to adopt consistent translations for scenes, but scenes are often compatible with multiple verbs (e.g., Gillette, Gleitman, Gleitman, & Lederer, 1999), and verbs

themselves adopt varying syntactic preferences. A car going down a mountain could either be described as *The car descends* (intransitive) or *The man drives the car* (transitive). Second, a translation strategy would vary with metalinguistic ability (e.g., what is this called in my language?), but adults and children often demonstrate comparable patterns of interpretation in similar verb-learning paradigms (Maguire et al., 2010; Papafragou & Selimis, 2010; Shafto et al., 2014). Finally, if English speakers translated novel verbs to known ones (e.g., *torg* to *descend*), then they should have also revealed an intransitive preference when internally caused verbs alternated between frames (i.e., Fully alternating familiarization). Instead, experience with transitives generated an equivocal preference that paralleled that of Japanese speakers. This suggests that syntactic judgments were mediated by experience with input statistics.

Our findings provide new insights into well-known difficulties that adult Japanese speakers face when learning English causatives (Montrul, 2001; Nagano, 2015). These challenges are often explained in terms of the subset principle (Berwick, 1985; Inagaki, 2001). Since L1 distinctions (e.g., fewer restrictions on verbs in Japanese) are a superset of L2 distinctions (e.g., more restrictions in English), negative evidence is required to block overgeneralizations. However, this is rarely available in the input. Yet, the subset principle does not explain cross-linguistic similarities in *transitive* judgments of internally caused verbs. After all, if Japanese speakers misapplied an L1 grammar, they should have incorrectly accepted transitives, even when these frames were absent in the current input. Instead, cross-linguistic effects emerged on *intransitive* judgments, suggesting that prior knowledge influenced current learning through participants' assessment of positive evidence. This pattern is consistent with Bayesian models that characterize L1 transfer effects as probabilistic inferences over the representations generating input statistics (Pajak, Fine, Kleinschmidt, & Jaeger, 2016). Together, this suggests that parallel algorithms may be used to interpret distributional evidence during L1 and L2 learning.

Finally, if existing knowledge is a filter for interpreting new input, then cross-linguistic differences may provide a useful analogy for understanding evolving learning strategies during development. By age five, English-speaking children bootstrap novel verb meanings via syntactic frames (Naigles, 1990; Yuan & Fisher, 2009) and interpret ambiguous frames via lexical biases (Snedeker & Trueswell, 2004; Snedeker & Yuan, 2008). For example, upon encountering verb-phrase (VP)-biased verbs (e.g., *Hit the seal with the pen*), children look to potential instruments in scenes (e.g., using the pen to hit the seal), and after noun-phrase (NP)-biased verbs (e.g., *Choose the seal with the pen*), they look to likely modifiers (e.g., the seal that's holding a pen). Notably, sentence frames and lexical biases vary in the quantity of experience needed to abstract meaning relations. Every sentence offers relevant information about how arguments map onto meanings (Fisher, 1996; Gleitman, 1990), but isolating lexical biases requires the presence of specific words (e.g., only *hit* sentences are relevant for abstracting *hit* properties) and the ability to track probabilistic behaviors across sentences (i.e., likelihood of VP- or NP-attachment). Thus, while lexical biases offers a reliable basis for calculating sentence meanings, acquiring this knowledge in the first place may require substantial input experience.

Nevertheless, since inexperience is a fact of development, children must adopt strategies for interpreting sentences when they know little about their language and when they know more. Early on, lexical statistics may be underinformative when children may have limited knowledge of what patterns to track. Moreover, there is no guarantee that verbs encountered in one context will emerge again in another (e.g., long intervals between instances of *giggle*). Faced with these hurdles, children may initially rely on knowledge of syntactic patterns shared across all verbs. In this sense, they may behave *as if* they are acquiring a generalist language. Over time, greater experience and linguistic knowledge may enable children to isolate lexically specific patterns. This, in turn, may lead to more adult-like approximations of sentence meanings during comprehension and production. While preliminary, this hypothesis is consistent with two notable patterns. First, 5- to 10-year-olds are more likely to overgeneralize transitive frames to infrequent verbs compared to frequent ones (Ambridge, Pine, Rowland, Jones, & Clark, 2009; Ambridge et al., 2008; Theakston, 2004). For

example, children consider the infrequent *giggled* (google n-gram: 1x per 10,000 words) to be more felicitous than the frequent *laughed* (17x per 10,000 words). Sentence-level effects parallel patterns in inflectional morphology, where 3- to 13-year-olds overregularize infrequent verbs (e.g., *feed* → *feeded*; 20x per 10,000 words) more so than frequent ones (e.g., *eat* → *eated*; 40x per 10,000 words) (Marchman, 1997; Marcus et al., 1992). Together, this suggests that relying on verb-general tendencies may be a broad strategy that learner recruit when limited experience prevents them from making more specific predictions. However, additional research is needed to flesh out this hypothesis within processing models of production and comprehension during development.

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Disclosure statement

Q4 No potential conflict of interest was reported by the authors.

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