

# A Semantics-Based Approach to the ‘No Negative Evidence’ Problem

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## Abstract

Previous studies have shown that children retreat from argument-structure overgeneralization errors (e.g., *\*Don't giggle me*) by inferring that frequently encountered verbs are unlikely to be grammatical in unattested constructions, and by making use of syntax-semantics correspondences (e.g., verbs denoting internally caused actions such as giggling cannot normally be used causatively). The present study tested a new account based on a unitary learning mechanism that combines both of these processes. Seventy-two participants (ages 5–6, 9–10, and adults) rated overgeneralization errors with higher (*\*The funny man's joke giggled Bart*) and lower (*\*The funny man giggled Bart*) degrees of direct external causation. The errors with more-direct causation were rated as less unacceptable than those with less-direct causation. This finding is consistent with the new account, under which children acquire—in an incremental and probabilistic fashion—the meaning of particular constructions (e.g., transitive causative = direct external causation) and particular verbs, rejecting generalizations where the incompatibility between the two is too great.

*Keywords:* Child language acquisition; Syntax; Semantics; Verb argument structure; Overgeneralization errors; No negative evidence problem; Construction semantics; *ILVACS*

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## 1. Introduction

The defining characteristic of human language is that it allows speakers to produce completely novel utterances as opposed to simply reproducing previously heard sentences. Recently, there has been much interest in how children acquire the abstract rules or schemas that underlie this productivity (e.g., Abbot-Smith, Lieven, & Tomasello, 2004; Gertner,

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Fisher, & Eisengart, 2006; Savage, Lieven, Theakston, & Tomasello, 2003; Thothathiri & Snedeker, 2008). A key (though perhaps underresearched) question in this debate is that of how, having acquired productive syntactic rules or constructions, children learn to appropriately restrict their usage in order to avoid producing utterances that are regarded as ungrammatical by adult speakers. For example, all native English speakers are able to produce utterances with novel verbs such as *The man pilked the ball* on the basis of hearing utterances such as *The ball pilked*, yet, at the same time, are able to *avoid* producing *\*The clown giggled the girl* despite hearing *The girl giggled*. Furthermore, children are known to actually produce overgeneralization errors of this type (e.g., *\*Don't giggle me*; *\*I'm just gonna fall this on her*; from Bowerman, 1982) before “retreating” from such overgeneralizations later in development. Arriving at an explanation of exactly how children acquire this capacity for restricted generalization represents “one of the most intriguing and difficult challenges” facing the field (Bowerman, 1988: 73), yet such an explanation must form the core of any successful theory of language acquisition.

Until recently, the available explanations for how this capacity for restricted generalization is acquired have proved problematic. Although parental feedback may alert children to some grammatical errors (Saxton, 2000), an additional mechanism is required to explain the fact that adults still regard as ungrammatical errors for which they are unlikely to have received such feedback during childhood (e.g., *\*The message emailed to John.*). The notion of “competition” (MacWhinney, 1987) can account for “unlearning” of simple errors for which there is a direct competitor in the input (e.g., *\*sitted* is blocked by *sat*) but struggles to explain *argument-structure* overgeneralization errors. These occur when the child uses a particular verb (e.g., the intransitive verb *giggle*) in an argument-structure construction in which it is not licensed in the adult grammar (e.g., the transitive causative [SUBJECT] [VERB] [OBJECT] construction), yielding, for example, *\*The joke giggled me.*<sup>1</sup> The problem here is that there is no direct alternative form to block the error.<sup>2</sup> In a recent study focusing on transitive-causative overgeneralization errors of this type, Ambridge, Pine, Rowland, and Young (2008) found support for two separate but compatible hypotheses concerning this generalization-then-restriction process (see also B. Ambridge, J. M. Pine, C. F. Rowland, & V. Clark, unpublished data, for converging evidence from the dative alternation).

### 1.1. Entrenchment hypothesis

Under the entrenchment hypothesis (Braine & Brooks, 1995), children retreat from such overgeneralizations probabilistically on the basis that the repeated presentation of a verb in one construction (e.g., *I giggled*) together with its absence in another (e.g., *\*The joke giggled me*) causes the learner to gradually infer that this verb may not be used in the non-attested construction. This hypothesis predicts that such argument-structure overgeneralization errors (e.g., *\*The clown laughed the man*) should be rated as least acceptable for high-frequency verbs, for which the correct usage will have become most “entrenched” (e.g., *laugh*), more acceptable for low-frequency verbs (e.g., *giggle*), and most acceptable for semantically matched novel verbs (*tamm*; meaning to laugh in a high-pitched manner).

In order to test this hypothesis, Ambridge et al. (2008) developed a ‘‘smiley-face’’ scale that allows even young children to provide graded judgments of sentence acceptability. Participants’ judgments followed the pattern predicted by this hypothesis for all age groups studied (5–6, 9–10, and adults), echoing previous findings observed in binary grammaticality-judgment and elicited-production studies (Brooks, Tomasello, Dodson, & Lewis, 1999; Theakston, 2004). One aim of the present study is to replicate this finding with a different set of verbs and sentence types.

### 1.2. Verb-semantic hypothesis

Under the semantic-verb-class account (Pinker, 1989), retreat from overgeneralization occurs gradually as children form semantic classes of verbs (i.e., classes of verbs denoting similar actions or events) that may appear in certain constructions. For example, ‘‘verbs of semivoluntary expression of emotion’’ such as *laugh* and *giggle* (Pinker, 1989: 303) form a class of verbs that can appear in the intransitive construction (e.g., *The man laughed/giggled*). However, such verbs are NOT members of a class of verbs that can appear in the transitive causative construction (e.g., the class of verbs of ‘‘motion around an axis’’ such as *spin*, *rotate*) and so are prohibited from appearing in that construction (hence the ungrammaticality of *\*The joke laughed/giggled me*). Errors are possible early in development before the semantic verb classes have been formed, but they cease when the child arrives at an adult-like set of classes. Ambridge et al. (2008) taught participants three novel verbs (*tamm*, *fudd*, *meeek*), each denoting an action whose semantics<sup>3</sup> were consistent with intransitive-only verb classes (novel types of *laughing*, *falling*, and *disappearing* events). The account predicts that participants will accept uses of the novel verbs in an intransitive construction (e.g., *The man tammed* [=laugh in a high-pitched manner]) because the semantics of the action denoted are consistent with those of an intransitive-only verb class, but will rate as unacceptable uses in a transitive construction (e.g., *\*The clown tammed the man*), as the semantics are not consistent with those of a transitive verb class. For adults and older children (9–10), this prediction was confirmed for all three novel verbs (see Brooks & Tomasello, 1999 for similar findings in a production study with children aged 4;6). For the younger children, this prediction was supported only for the novel *laughing* verb, which also displayed the largest effect with the older groups. Ambridge et al. (2008) argued that this is because the novel *laughing* verb has semantics that are more inherently internally caused than the novel *disappearing* or *falling* verb. Indeed this effect also held across the familiar *falling*, *disappearing*, and *laughing* verbs used in this previous study. One aim of the present study was to investigate whether the finding that causative overgeneralization errors are rated as less acceptable for *laughing* than *disappearing* verbs holds for a new set of stimuli. A more important aim was to conduct a preliminary investigation of a new hypothesis inspired by this previous finding.

### 1.3. The ILVACS account: Integrating the two hypotheses

Although both the entrenchment and verb-semantic hypotheses have received empirical support, neither hypothesis on its own can explain the pattern of data observed over these

studies. The entrenchment hypothesis contains no mechanism for forming semantic verb classes, while the semantic-verb-class hypothesis, in the form proposed by Pinker (1989), rules out a role for entrenchment, at least beyond a certain point in development, as “an adult’s narrow-class rules correspond to the verbs that happen to alternate in his...lexicon at a maturationally determined critical point” (p. 349). The main goal of the present paper is to propose and conduct a preliminary test of a new account based on a single learning mechanism that yields both of these effects.

The starting point for this new account is the finding of Ambridge et al. (2008) that transitive causative overgeneralization errors were rated as less acceptable for (English and novel) *laughing* verbs than *disappearing* or *falling* verbs. Many authors have noted that verbs (or—more properly—the actions denoted by those verbs in particular sentence contexts) appear to lie on a gradient with respect to the extent to which they are semantically consistent with the meanings of (and hence are [un/]grammatical in) particular constructions. For the transitive causative construction, the relevant gradient would appear to be the extent to which the actions denoted “are directly causable by an external agent” (Pinker, 1989: 302). Verbs denoting actions that require an external causer *require* the transitive causative construction (e.g., *The man washed the clothes*), with the intransitive prohibited (e.g., *\*The clothes washed*).<sup>4</sup> Verbs denoting actions that “have internal causes that would make any external prodding indirect” (p. 302) *prohibit* the transitive causative construction (e.g., *\*The clown laughed the man*), while verbs denoting events for which causation can be viewed as either internal or external permit both (e.g., *The man rolled the ball/The ball rolled*) (Wolff, 2003).

One plausible learning mechanism, then, would be for the child to incrementally acquire the semantics of both particular verbs (or, more properly, of the actions denoted by them) and particular constructions. Overgeneralization errors would cease as the child learned enough about the semantics of the relevant construction (e.g., *direct external causation*) and of the actions associated with particular verbs (e.g., *internal, semi-voluntary causation*) to detect a mismatch. In subsequent discussion, we will refer to this proposal as the *Incremental Learning of Verb and Construction Semantics (ILVACS)* account.

On this account, “entrenchment” is conceptualized not as a simple statistical tallying of the number of times that a verb (e.g., *giggle* or *laugh*) has occurred in a particular construction (e.g., *SVO*). Rather, repeated presentation of a verb strengthens the (here, *single-participant, internally caused*) semantic representation of the actions denoted by that verb. Thus, transitive causative overgeneralization errors are rated as less acceptable with *laugh* than *giggle* because the former is more strongly associated with the semantics of internal causation—and hence more resistant to coercion into a semantically opposed construction (i.e., *SVO* = direct external causation)—than the latter. This mechanism would also give rise to apparent effects of semantic verb class, as verbs denoting semantically similar actions will inevitably be semantically (in/)compatible with a similar set of constructions.

#### 1.4. Testing the ILVACS account

The central assumption of the *ILVACS* account is that children reject (or cease to produce) generalizations for which the clash between the semantics of the relevant

construction and of the action denoted by the verb is too great. This predicts that it should be possible to manipulate the extent to which particular transitive causative overgeneralization errors are considered to be ungrammatical by manipulating the semantics of the action described by the verb along the dimension of directness-of-external-causation. Since this construction is associated with the meaning of direct external causation, this clash will be reduced (and hence acceptability increased) when the extent to which the action denoted by the verb is *also* one of direct external causation is increased.

One way to manipulate the semantics of the action described by the verb along the dimension of directness-of-external-causation is to manipulate the sentence context (i.e., properties of other items in the sentence). For events of causation, the directness of this causation can be manipulated by manipulating properties of the agent. Consider the following overgeneralization errors (with the agent underlined).

*\*The magician disappeared Bart* / *\*The magician's spell disappeared Bart*  
*\*The funny man giggled Bart* / *\*The funny man's joke giggled Bart*

For the sentences on the right, the magician/funny man performs an action (casting a spell or telling a joke) that in turn causes the *disappearing/giggling* event. In terms of a chain of causation (e.g., Talmy, 2000), we might represent these events as follows:

*Magician CAUSE spell CAUSE Bart disappear*  
*Funny man CAUSE joke CAUSE Bart giggle*

For the sentences on the left, the event is similar, but the intervening cause is not specified.

*Magician CAUSE ??? CAUSE Bart disappear*  
*Funny man CAUSE ??? CAUSE Bart giggle*

Although the intervening cause need not necessarily be *casting a spell* or *telling a joke*, it is clear that there is nevertheless *some* intervening cause (e.g., the magician waving a wand or the funny man pulling a face) that is responsible for the disappearance or laughter. Thus, *The magician's spell* and *The funny man's joke* (one link in the causal chain from the *disappearing/giggling* event) are more direct causers of these events than *The magician* and *The funny man* (two links in the causal chain from these events), respectively. Consequently, the action denoted by the verb is more compatible with the notion of direct external causation (the meaning associated with the transitive causative construction) for the sentences *\*The magician's spell disappeared Bart* and *\*The funny man's joke giggled Bart* than for the sentences *\*The magician disappeared Bart* / *\*The funny man giggled Bart* (even though the verb itself is the same in each sentence pair).<sup>5</sup> Thus, the prediction of our new account is that transitive causative overgeneralization errors of the former type (e.g., *\*The magician's spell disappeared Bart*) should be rated as more acceptable than errors of the latter type (e.g., *\*The magician disappeared Bart*). The aim of the present study is to test this prediction.

## 2. Method

### 2.1. Participants

Participants were 72 normally developing monolingual speakers of British English; 24 aged 5–6 (Mean age = 5;8), 24 aged 9–10 ( $M = 9;8$ ), and 24 adults ( $M = 20;1$ ). These age groups were chosen to allow comparison with the findings of a previous study of transitive causative overgeneralization errors (Ambridge et al., 2008).

### 2.2. Design

The experiment used a  $2 \times 3 \times 2 \times 3$  mixed design with within-subjects variables of semantic verb class (“semivoluntary expression of emotion,” “going out of existence”; Pinker, 1989: 303), verb frequency (high, medium, low), and directness of causality (more direct, less direct). Age (5–6/9–10/adults) was analyzed as a between-subjects variable. Following Ambridge et al. (2008), the dependent variable was a “preference for grammatical use” or “difference” score calculated by subtracting each participant’s acceptability rating for a particular ungrammatical sentence (e.g., *\*The magician disappeared Bart*) from that participant’s rating of the equivalent grammatical control sentence (e.g., *The magician made Bart disappear*).<sup>6</sup> The advantage of using this score as opposed to simply ratings of the ungrammatical sentences is that it corrects for any general (dis)preferences participants may have for particular verbs, or for the use of particular NPs as AGENTS or PATIENTS (e.g., Ambridge et al., 2008, found that participants generally showed a slight dispreference for sentences with low-frequency verbs, even when used grammatically).

### 2.3. Materials and procedure

Twenty-four test sentences were constructed in accordance with the design outlined above:

*\*The funny man(’s joke) laughed Lisa/giggled Bart/chuckled Homer*

*The funny man(’s joke) made Lisa laugh/Bart giggle/Homer chuckle*

*\*The magician(’s spell) disappeared Bart/vanished Homer/evaporated Lisa*

*The magician(’s spell) made Bart disappear/Homer vanish/Lisa evaporate*

High-, medium-, and low-frequency verbs were chosen from semantic verb classes outlined by Pinker (1989: 303). Frequencies were taken from the British National Corpus<sup>7</sup> and rank order checked against data from maternal speech in the CHILDES database.

A recording of each sentence, along with a cartoon animation illustrating the intended meaning, was presented using a laptop computer. To ensure that, in all cases, a (sometimes unspecified) intervening cause was understood to be present, the magician always waved a wand, producing a burst of stars and a sound effect, while the “funny man” told a joke.



Participants rated the sentences on a five-point “smiley face” scale using the procedure and practice sentences (based on overgeneralizations of the dative alternation) outlined in Ambridge et al. (2008). Participants completed the trials in random order.

### 3. Results

The mean preferences for grammatical (periphrastic causative) over ungrammatical (transitive causative) uses of each verb are shown in Table 1.

The data were analyzed using a  $2 \times 3 \times 2 \times 3$  ANOVA with within-subjects variables of semantic verb class (“semivoluntary expression of emotion,” “going out of existence”; Pinker, 1989: 303), verb frequency (high, medium, low), and directness of causality (more direct, less direct) and the between-subjects variable of age (5–6/9–10/adults). The dependent variable was the preference for the grammatical (periphrastic causative) version of each sentence over its ungrammatical (transitive causative) equivalent.<sup>8</sup>

#### 3.1. Testing the verb semantics and entrenchment hypotheses

As predicted by the verb semantics approach (and replicating the finding of Ambridge et al., 2008), participants were more sensitive to grammatical versus ungrammatical uses of the verbs of semivoluntary expression of emotion (Mean difference score = 2.13 points on the five-point scale;  $SE = 0.09$ ) than the verbs of going out of existence ( $M = 1.34$ ,

Table 1

Mean ratings of acceptability (preference for grammatical periphrastic causative over ungrammatical transitive causative use on the five-point scale) for each sentence in the study (and standard deviations)

Verb (Freq)	Causality	5–6 Year Olds	9–10 Year Olds	Adults	Total
		<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )	<i>M</i> ( <i>SD</i> )
<i>Verbs of going out of existence</i>					
Disappear (High)	Direct	1.29 (1.55)	1.71 (1.23)	2.75 (0.74)	1.92 (1.35)
	Indirect	1.46 (1.25)	1.83 (1.27)	2.71 (0.95)	2.00 (1.27)
Vanish (Medium)	Direct	0.50 (1.10)	0.88 (1.15)	2.21 (1.06)	1.19 (1.32)
	Indirect	1.33 (1.63)	1.46 (1.02)	2.63 (1.01)	1.81 (1.37)
Evaporate (Low)	Direct	0.50 (1.69)	0.67 (1.34)	0.88 (1.30)	0.68 (1.44)
	Indirect	0.42 (1.47)	0.17 (1.01)	0.71 (0.95)	0.43 (1.17)
<i>Verbs of semivoluntary expression of emotion</i>					
Laugh (High)	Direct	1.71 (1.83)	2.58 (1.06)	2.79 (0.93)	2.36 (1.40)
	Indirect	1.83 (1.37)	2.67 (1.05)	3.00 (1.10)	2.50 (1.27)
Giggle (Medium)	Direct	1.46 (1.41)	2.04 (0.91)	2.71 (0.95)	2.07 (1.21)
	Indirect	1.21 (1.61)	2.42 (0.93)	2.88 (0.95)	2.17 (1.38)
Chuckle (Low)	Direct	0.29 (1.16)	1.54 (0.88)	2.63 (1.13)	1.49 (1.42)
	Indirect	1.50 (1.38)	2.29 (1.08)	2.83 (1.20)	2.21 (1.33)

*Note:* Sentences were rated on a five-point scale with 5 indicating the highest degree of acceptability. Thus, higher figures (Max = 4) indicate greater ungrammaticality of the transitive causative sentence (relative to its grammatical periphrastic causative counterpart).

$SE = 0.09$ ), as revealed by a main effect of semantic verb class [ $F(1, 69) = 78.28$ ,  $p < .001$ ,  $\eta^2 = 0.53$ ]. This would seem to be due to the fact that the verbs of semivoluntary expression of emotion denote actions that are more internally caused than verbs of going out of existence, and hence are more semantically incompatible with the transitive causative construction. A significant interaction of semantic verb class by frequency [ $F(2, 138) = 10.85$ ,  $p < .001$ ,  $\eta^2 = 0.14$ ] reflects the fact that the magnitude of this class effect (while still significant at  $p < .001$  for each level of verb frequency independently) increases as verb frequency decreases. There are two likely reasons for this.

First, overgeneralizations with high-frequency verbs are always rated as extremely unacceptable, regardless of their verb class. This finding was observed in both the study of Ambridge et al. (2008) and the present study (where, e.g., adults rated such errors as approximately three points less acceptable than their grammatical equivalents on the five-point scale). Thus, a floor effect is observed: Participants consider overgeneralization errors with the high-frequency verbs to be so unacceptable that semantic manipulations have little effect on their judgments.

Second, one of the low-frequency items, *evaporate*, probably reflects a mistaken classification. This verb was assumed to be a member of Pinker's (1989:130) class of "verbs of coming into or going out of existence." However, on reflection, *evaporate* may be more accurately classified as a "change of state" verb (similar to *melt* or *boil*) and, indeed, is classified as such by Levin (1993). The observed interaction partly reflects the fact that the effect for overgeneralization errors to be rated as less acceptable for verbs of semivoluntary expression of emotion than going out of existence was largest for the low-frequency verbs (i.e., *chuckle* and *evaporate*). Since participants in fact judged *evaporate* to be *acceptable* in the transitive causative construction (relative to periphrastic causative uses), it is not surprising that transitive causative uses of *evaporate* were rated as considerably more acceptable than transitive causative uses of *chuckle*.

As predicted by the entrenchment hypothesis, participants' preference for grammatical over ungrammatical uses was greatest for the high-frequency verbs ( $M = 2.19$  points on the five-point scale,  $SE = 0.09$ ), lower for the medium-frequency verbs ( $M = 1.81$ ,  $SE = 0.09$ ), and lower again for the low-frequency verbs ( $M = 1.20$ ,  $SE = 0.09$ ) with all comparisons significant at  $p < .01$  [Main effect of frequency:  $F(2, 138) = 58.15$ ,  $p < .001$ ,  $\eta^2 = 0.56$ ]. Inspection of the frequency by verb class interaction (see above for statistics) revealed that this three-way frequency effect (while still statistically significant for each verb class independently) was greater in magnitude for the verbs of going out of existence (all comparisons  $p < .001$ ) than the verbs of semivoluntary expression of emotion (all comparisons  $p < .03$ ). This reflects a second floor effect: Participants consider transitive causative uses of verbs of semivoluntary expression of emotion to be extremely unacceptable for semantic reasons: They are inherently internally caused. Thus, 5 year olds reject such sentences in a judgment task, even with novel verbs (Ambridge et al., 2008). Consequently, frequency effects are modest for this class, as overgeneralizations are rated as extremely unacceptable even for low-frequency verbs. Increasing the frequency of the verb cannot "persuade" participants to consider such overgeneralizations as more ungrammatical than they already do on the basis of verb semantics.



### 3.2. Developmental effects

Participants' preference for grammatical (periphrastic causative) over ungrammatical (transitive causative) sentences was largest for the adults ( $M = 2.39$  points on the five-point scale,  $SE = 0.13$ ), smaller for the 9–10 year olds ( $M = 1.69$ ,  $SE = 0.13$ ), and smallest for the 5–6 year olds ( $M = 1.13$ ,  $SE = 0.13$ ; all comparisons  $p < .005$  or better) as revealed by a main effect of age [ $F(2, 69) = 25.62$ ,  $p < .001$ ,  $\eta^2 = 0.43$ ]. It is difficult to know whether this effect is caused by increased learning of verb and construction semantics (or increased entrenchment) over time, or whether the results simply become less noisy with age (as, e.g., the scale is used more appropriately).

A significant interaction of age by semantic verb class was observed [ $F(2, 69) = 5.43$ ,  $p = .006$ ,  $\eta^2 = 0.14$ ] such that this developmental effect was more pronounced for verbs of semivoluntary expression of emotion (all comparisons significant at  $p < .01$ ) than for verbs of going out of existence, where the two child groups do not differ significantly (both other comparisons significant at  $p < .01$ ). This pattern is illustrated in Fig. 1. Between 5–6 and 9–10, children's sensitivity to ungrammatical uses of verbs of semivoluntary expression increases by approximately one point on the scale, while sensitivity to ungrammatical uses of verbs of going out of existence remains static. This reflects the fact that the former are more semantically incompatible with the transitive causative construction than the latter (as indicated by the main effect of semantic verb class).

A significant three-way interaction of age by semantic verb class by frequency [ $F(4, 38) = 4.46$ ,  $p = .002$ ,  $\eta^2 = 0.12$ ] was also observed. This interaction (see Fig. 2) reflects the fact that the single item *evaporate* is an exception to the general pattern illustrated in Fig. 1 whereby sensitivity to ungrammatical use occurs by 9–10 for verbs of semivoluntary expression of emotion, but later for verbs of going out of existence. *Evaporate* is an exception to this pattern because transitive causative uses are never rated as ungrammatical, even

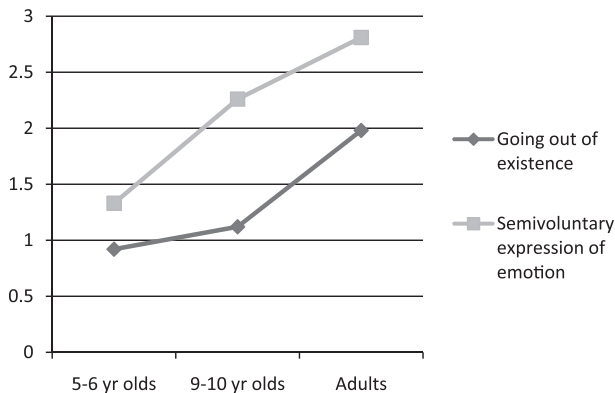


Fig. 1. Preference for grammatical (periphrastic causative) over ungrammatical (transitive causative) verb uses (as measured in points on the five-point scale, as shown on the Y axis) increases for verbs of semivoluntary expression of emotion before verbs of going out of existence.

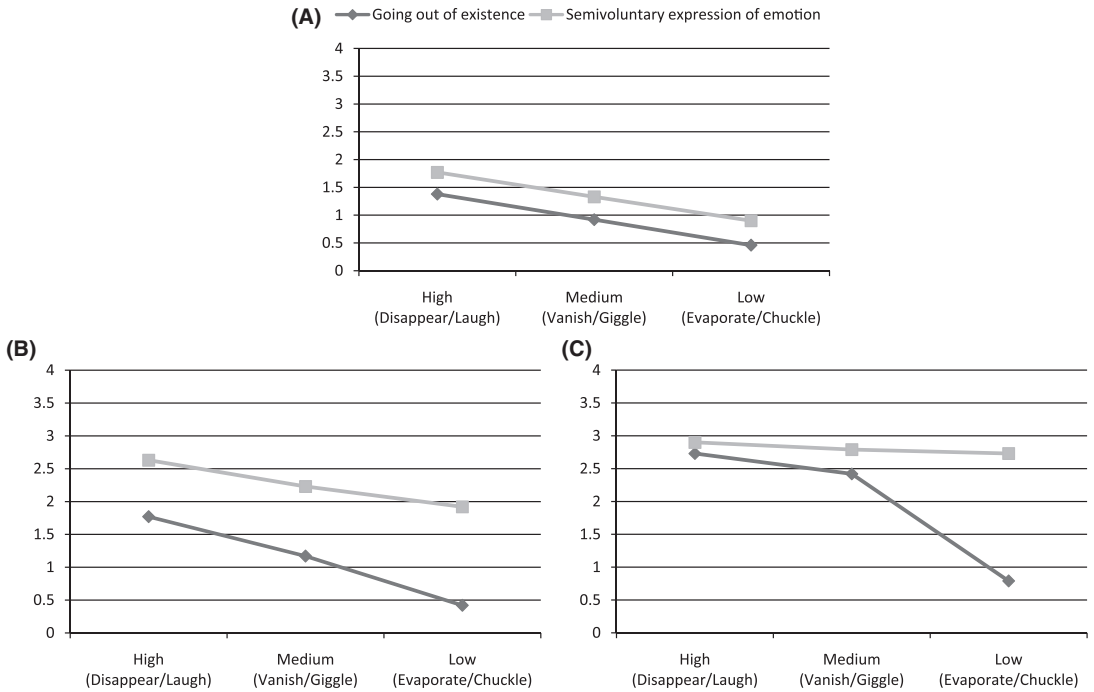


Fig. 2. Preference for grammatical (periphrastic causative) over ungrammatical (transitive causative) verb uses (as measured in points on the five-point scale, as shown on the Y axis) by frequency (X axis), for 5–6 year olds (A), 9–10 year olds (B), and adults (C).

by adults. Thus, this three-way interaction is simply a consequence of the misclassification of *evaporate* (as discussed above).

### 3.3. Testing the ILVACS account

The results presented so far provide support for both the entrenchment and verb semantics hypotheses, and they demonstrate that both of these effects appear to increase with age. As discussed in the introduction, the *ILVACS* account additionally predicts that participants should rate transitive causative uses of intransitive-only verbs as more acceptable (i.e., the difference score should be lower) when the sentence denotes a higher degree of direct external causation.

In line with this prediction, participants rated transitive causative uses as significantly more acceptable (relative to periphrastic causative uses) for the sentences involving more direct causation ( $M = 1.62, SE = 0.08$ ) than less direct causation [ $M = 1.85, SE = 0.08; F(1, 69) = 13.04, p = .001, \eta^2 = 0.16$ ]. Interestingly, no interaction with age was observed, indicating that even the youngest group show some sensitivity to the directness of causality manipulation.

There was, however, a significant interaction of causality by class by frequency [ $F(2, 146) = 9.10, p < .001, \eta^2 = 0.12$ ]. Analysis of this interaction showed that although the

means were in the predicted direction for every verb (except *evaporate*, which is a misclassification), only *vanish* (indirect  $M = 1.80$ ,  $SE = 0.15$  > direct  $M = 1.19$ ,  $SE = 0.13$ ) and *chuckle* (indirect  $M = 2.21$ ,  $SE = 0.15$  > direct  $M = 1.49$ ,  $SE = 0.13$ ) showed a significant cause effect when examined in isolation ( $p < .001$  in both cases). The most straightforward interpretation of this pattern is that the causality effect is difficult to detect for verbs that are subject to the floor effects discussed above. The causality effect does not reach significance for the high-frequency verbs *disappear* and *laugh* because high-frequency intransitive verbs are always rated as extremely ungrammatical in transitive causative sentences, with other factors therefore having limited effect. The causality effect does not reach significance for *giggle* because verbs of semivoluntary expression of emotion are also always rated as extremely ungrammatical in transitive causative sentences. Again, this means that other factors can have only a limited effect. Thus, the cause effect is only observed when these two floor effects conspire least: for the low-frequency verb of semivoluntary expression of emotion (*chuckle*) and for the medium- (*vanish*) and, in principle, low-frequency verb of going out of existence (though in practice, the misclassification of *evaporate* means that no such verb was included in the study).

#### 4. Discussion

In the present study, twenty-four 5–6 year olds, twenty-four 9–10 year olds, and Twenty four adults rated ungrammatical transitive causative uses (and—as a control—grammatical periphrastic causative uses) of high-, medium-, and low-frequency verbs of semivoluntary expression of emotion (*giggle*, *laugh*, and *chuckle*) and going out of existence (*disappear*, *vanish*, *evaporate*) in sentence contexts with a higher and lower degree of direct external causation (e.g., *\*The funny man's joke giggled Bart* vs. *\*The funny man giggled Bart*). Three findings emerged, all of which are consistent with the *Incremental Learning of Verb and Construction Semantics (ILVACS)* account.

First, participants rated transitive causative overgeneralization errors as less acceptable with verbs of semivoluntary expression of emotion (*giggle*, *laugh*, and *chuckle*) than verbs of going out of existence (*disappear*, *vanish*, *evaporate*), which are associated with a higher degree of potentially external causation. Second, overgeneralization errors were rated as least acceptable with high-frequency verbs, more acceptable with medium-frequency verbs, and most acceptable with low-frequency verbs. Third, and most importantly, participants rated transitive causative overgeneralization errors as significantly more acceptable when the directness of causality was increased by specifying as the agent a more direct cause of the action (e.g., *\*The funny man's joke giggled Bart* was rated as significantly more acceptable than *\*The funny man giggled Bart*).

All these findings are consistent with the *ILVACS* account of the retreat from argument-structure overgeneralization proposed in this paper. Under this account, the child retreats from error by acquiring—in an incremental and probabilistic fashion—the meaning of both particular constructions (e.g., transitive causative = direct external causation) and of the actions denoted by particular verbs, rejecting generalizations where the incompatibility

between the two is too great for the required “coercion” to occur. Of course, we must acknowledge that the directness-of-causality effect observed provides only preliminary, somewhat indirect support for the hypothesis. Nevertheless, it is worth noting that even if we lay the effect of directness of causality to one side—the *ILVACS* account represents the only current proposal that can explain, at the same time, the effect of *both* verb semantics and entrenchment observed in the present study (and in many previous studies including Ambridge et al., 2008 unpublished data; Brooks et al., 1999; Brooks & Tomasello, 1999; Gropen, Pinker, Hollander, Goldberg, & Wilson, 1989; Gropen, Pinker, Hollander, & Goldberg, 1991; Theakston, 2004).

It is important to make explicit the ways in which our proposal is novel (i.e., differs from previous accounts that acknowledge a role for both entrenchment and verb semantics). As we see it, the difference is as follows: Even among authors who acknowledge an important role for verb semantics, all previous proposals (of which we are aware) characterize entrenchment as a process of pure statistical tallying of the number of occurrences of a verb (e.g., *giggle*) in a particular (formal) argument-structure pattern (e.g., SV inchoative intransitive). This view is implicit in studies such as that of Wonnacott, Newport, and Tanenhaus (2008) who investigated statistical frequency (entrenchment) effects in a toy grammar where two formal argument structure patterns are paired with a single meaning. The view is explicit in the account of Tomasello (2003: 130) who argues that “entrenchment works early...and semantic subclasses [of verbs] begin to work later.” The claim is that—early in development—entrenchment can work as a purely formal statistical process, without reference to the learning of associations between formal syntactic patterns (e.g., SVO) and construction semantics (e.g., direct external causation). Bowerman and Croft (2007) go further still, arguing that there is “remarkably little evidence that children are constrained by the narrow-range semantic categories that are relevant for the causative alternation, either early or late in development” (emphasis in original).

The present proposal specifically denies the claim that entrenchment can operate without reference to verb semantics. On the contrary, entrenchment *is* entrenchment of verb semantics. Repeated presentation of *laugh* in the intransitive inchoative construction causes the semantic representation of the verb to become more associated with internal as opposed to external causation. Hence it is only by operating over verb semantics that entrenchment of *laugh* in the intransitive inchoative construction causes this verb to come to be considered ungrammatical in (i.e., semantically inconsistent with) the transitive causative construction. To be sure, entrenchment can operate before a full set of adult-like “verb classes” has been formed (and this is why it might look as though purely statistical entrenchment exerts an effect before verb semantics), but it does not—under the present proposal—operate independently of verb semantics.

Leaving the data aside, from a purely theoretical point of view, it seems odd to posit that children would initially ignore a possible source of information concerning verb’s argument structure privileges (i.e., verb and construction semantics) in favor of another (i.e., statistical frequency information). It cannot be that the former cue is unavailable as (a) children clearly have at least some understanding of the meanings of the verbs they produce and (b) the very fact that such errors (e.g., *\*Don’t giggle me*) are produced at all demonstrates some

knowledge of the semantics associated with the construction (the direct-causation meaning of the construction is the very motivation for such overgeneralizations).

On the other hand, any account that does posit a purely statistical form of entrenchment that can operate without reference to verb semantics (e.g., Bowerman & Croft, 2007; Tomasello, 2003) would struggle to explain the systematic differences reported here between acceptability judgments of sentences with more and less direct causal agents (e.g., *\*The funny man/funny man's joke giggled Bart*. As the two sentences involve overgeneralizations of the same verb into—at the level of argument structure—the same construction, any difference between the two is difficult to explain on a purely statistical entrenchment account. One would have to argue that entrenchment explains the fact that children know that both sentences are ungrammatical, while a separate process involving the formation of semantic verb classes leads them to deem one more unacceptable than the other. As a more parsimonious alternative, the present proposal and other possible accounts that integrate the two processes deserve investigation.

The *ILVACS* account makes a potentially surprising prediction with regard to pre-emption. Virtually all authors who have discussed the no-negative evidence problem have assumed that preemption must be an important part of the solution (e.g., Bowerman, 1988; Brooks & Tomasello, 1999; Goldberg, 1995; MacWhinney, 1987; Tomasello, 2003). Pre-emption occurs when the child hears an alternative grammatical form that preempts (i.e., blocks) the error. For example, encountering *giggle* in a periphrastic causative construction (*NP1 made NP2 giggle*; e.g., *The funny man made Bart giggle*) increasingly leads the learner to infer that the transitive causative version (*NP1 giggled NP2*; e.g., *\*The funny man giggled Bart*) is ungrammatical. The present proposal predicts that—while preemption may be helpful in restricting argument structure overgeneralizations—it is not necessary. If, as this proposal claims, entrenchment works by subtly and incrementally changing the semantic representation of the verb, repeatedly hearing *giggle* paired with a non-directly caused event will be sufficient for the learner to acquire the verb's non-causative semantics, and hence to reject uses of it in the transitive causative construction. This will apply whenever *giggle* is paired with a non-directly caused event, whether it appears in an intransitive frame (e.g., *Bart giggled*) or a ‘preempting’ periphrastic causative (e.g., *The funny man made Bart giggle*).

Thus, perhaps surprisingly, this new account predicts that children will be able to reject transitive causative uses of such verbs (e.g., *giggle*) without *ever* hearing them used in ‘preempting’ constructions (here the periphrastic causative). Indeed, although preemption has been widely considered to be important in the retreat from argument-structure overgeneralization errors, it is again possible to argue against this assumption on purely theoretical grounds. Adult speakers are able to reject overgeneralizations of very low-frequency verbs (e.g., *\*The funny man chortled/sniggered/tittered Bart*) even though it is unlikely that they have encountered ‘preempting’ alternative sentences (e.g., *NP made NP chortle/snigger/titter*) for all of them. Indeed, even the youngest children studied by Ambridge et al. (2008) were able to reject transitive causative uses of *novel* laughing verbs which had never been presented in periphrastic causative sentences. This would leave pre-emption with a similar status to adult corrections; useful, but not necessary, for the retreat from argument-structure

overgeneralization errors. If preemption is indeed to be rejected on purely theoretical grounds (see Bowerman, 1988, for other arguments against pre-emption), an advantage of the *ILVACS* account is that it can explain children's retreat from argument-structure overgeneralization errors without having to make reference to this potentially problematic notion.

In conclusion, there are many questions to be addressed before the field arrives at a complete understanding of the learning mechanism that children use to retreat from argument-structure overgeneralization errors. However, the findings of both the present study and previous work (e.g., Ambridge et al., 2008, unpublished data) suggest that what is required is an account in which entrenchment and verb semantics work together. In the present study, we have proposed—and provided preliminary support for—one such account, as well as highlighting further experimental effects for which any successful theory of the retreat from argument-structure overgeneralization errors must account.

## Notes

1. Errors of this type—where an inchoative intransitive verb such as *giggle* (as opposed to an unspecified-object intransitive verb such as *eat*) is erroneously used in a transitive causative construction—are the focus of this paper.
2. It has been argued (e.g., Brooks & Tomasello, 1999) that an indirect “competitor” such as *The joke made me giggle* might preempt the error. We consider this “preemption” account in the discussion.
3. As we will see later, it is the semantics of the particular ACTION denoted by a verb *in a given context* (and not of the VERB in general) that determine whether a verb can felicitously be used in a particular construction (see next footnote and associated main text).
4. This example illustrates why it is the semantics of the particular ACTION denoted by a verb *in a given context* (and not of the VERB in general) that determine whether a verb can be used in a particular construction. When the verb *wash* denotes an action of direct (unmediated) physical causation, the transitive construction is required. However, when the *same verb* is used to describe an event involving indirect (mediated) causation, this construction cannot be used. For example, *The man washed the clothes* is not a felicitous description of an event where the man paid a drycleaner to wash the clothes (c.f., *The man had the clothes washed*).
5. Although animates are more likely than inanimates to be causal agents *in general*, this by no means implies that there are not scenarios (such as the present scenario) in which an inanimate can be a “better” causal agent than an animate (see Levin & Rappaport Hovav, 1995, 2005).
6. In the present study, periphrastic causatives (e.g., *The magician made Bart disappear*) were used as control sentences, unlike the study of Ambridge et al. (2008) where simple intransitives (e.g., *Bart disappeared*) were used. We decided to use periphrastic causatives (rather than intransitives) as control sentences as they are more closely



matched to the sentences of interest (e.g., \**The magician disappeared Bart*) in that they include the same number of participants, denote the same event, and are more closely matched in length.

7. BNC all texts (VERB uses only) *Disappear*: 5,317; *Vanish*: 1,518; *Evaporate*: 490; *Laugh*: 9,115; *Giggle*: 686; *Chuckle*: 563.
8. In principle, it would be more appropriate to use raw scores (as opposed to difference scores) for some analyses. In practice, the use of either dependent measure gives an identical pattern of significant and nonsignificant comparisons. For consistency we therefore report the results of difference-score analyses in all cases.

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