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AGUADO-OREA, Javier <<http://orcid.org/0000-0002-2311-5295>>, OTERO, Nuria and AMBRIDGE, Ben

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Javier Aguado-Orea\*, Nuria Otero and Ben Ambridge

# Statistics and semantics in the acquisition of Spanish word order: Testing two accounts of the retreat from locative overgeneralization errors

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**Abstract:** Native speakers of Spanish (children aged 6–7, 10–11 and adults) rated grammatical and ungrammatical ground- and figure-locative sentences with high frequency, low frequency and novel verbs (e. g., *Lisa llenó/forró/nupó la caja con papel*; \**Lisa llenó/forró/nupó papel en la caja*, ‘*Lisa filled/lined/nupped the box with paper*’; ‘*Lisa filled/lined/nupped paper into the box*’) using a 5-point scale. Echoing the findings of a previous English study (a language with some important syntactic differences relevant to the locative), participants rated errors as least acceptable with high frequency verbs, more acceptable with low frequency verbs, and most acceptable with novel verbs, suggesting that learners retreat from error using statistically-based learning mechanisms regardless of the target language. In support of the semantic verb class hypothesis, adults showed evidence of using the meanings assigned to novel verbs to determine the locative constructions in which they can and cannot appear. However, unlike in the previous English study, the child groups did not. We conclude that the more flexible word order exhibited by Spanish, as compared to English, may make these types of regularities more difficult to discern.

**Keywords:** child language acquisition, Spanish, locatives, argument structure overgeneralization errors, verb semantics, statistical learning, entrenchment, pre-emption

Children face a paradox when they learn their target language/s (Braine 1971; Baker 1979; Bowerman 1988; Pinker 1989). On the one hand, they must form generalizations that allow them to use verbs in argument structure constructions in which they have not been encountered in the input. Constructions involving figure and ground locatives are an interesting example. For instance, in a language like Spanish, on the basis of hearing figure-locatives (1) and ground-locatives (2) with the same verb, children could set up a productive generalization that allows them to use in the latter construction verbs that have been attested solely in the former construction, and vice versa (3).

1. Homer salpicó agua a Marge [= Homer splashed water onto Marge]
2. Homer salpicó a Marge con agua [= Homer splashed Marge with water]
3. Lisa regó agua en las rosas [= Lisa sprayed water onto the roses]  $\leftarrow \rightarrow$  Lisa regó las rosas con agua  
[= Lisa sprayed the roses with water]

Indeed, without this ability, language would consist of nothing more than an inventory of rote-learned utterances; a position that has not been taken seriously since Chomsky’s (1959) review of Skinner’s (1957) *Verbal Behavior*.

On the other hand, in order to avoid producing utterances that adult speakers would regard as ungrammatical, children must somehow learn to restrict these generalizations. For example, over-

\*Corresponding author: Javier Aguado-Orea, Sheffield Hallam University, Sheffield, UK, E-mail: J.Aguado-Orea@shu.ac.uk

Nuria Otero, Universidad de Alcalá, Alcalá, Spain

Ben Ambridge, University of Liverpool, ESRC International Centre for Language and Communicative Development (LuCiD), Liverpool, UK

application of the generalization above (3) in the *figure*→*ground* and *ground*→*figure* direction would result in errors such as (4) and (5) respectively

4. Homer vertió agua en la taza [= Homer poured water into the cup] → \*Homer vertió la taza con agua [= \*Homer poured the cup with water]
5. Lisa llenó la caja de papel [= Lisa filled the box with paper] → \*Lisa llenó papel en la caja [= \*Lisa filled paper into the box]

The task of restricting these generalizations is not trivial. Many children pass through a stage in which they produce exactly these types of overgeneralization errors, as observed in both experimental studies (Gropen et al. 1991a; Gropen et al. 1991b) and – as for the following examples – naturalistic corpora (Bowerman 1988):

*figure*→*ground*

6. \*Mommy, I poured you [M: You poured me?] Yeah, with water (2;11)
7. \*I don't want it because I spilled it of orange juice (4;11)

*ground*→*figure*

8. \*I'm gonna cover a screen over me (4;5)
9. \*Can I fill some salt into the bear [-shaped salt shaker]? (5;0)

Although most previous research into the so-called *locative alternation* has been conducted in English (e. g., Gropen et al. 1991a; Gropen et al. 1991b; Bidgood et al. 2014), exactly the same paradox applies to learners of many other languages, including Spanish: As the above examples show, while many verbs (e. g., *salpicar*, 'to splash') may appear in both the *figure*- and *ground*-locative, other verbs are restricted to either the *figure*-locative construction (e. g., *verter*, 'to pour') or the *ground* locative construction (e. g., *llenar*, 'to fill'). Thus Spanish children, too, must learn these restrictions, while maintaining the ability to generalize compatible locative verbs into non-attested constructions.

The situation is complicated by the fact that Spanish (like other Romance languages) is considerably more flexible than English (and other Germanic languages) with regard to word order (see Butt and Benjamin 1996; Brown and Rivas 2011; Serrano 2014, and references cited therein).

SVO is the basic word order in Spanish, with the subject preceding the verb in pragmatically unmarked independent declarative clauses with two full NPs... Word order is flexible in that the subject, when expressed, may occupy either a pre- or post-verbal position with the different permutations of sentence types (SVO, VOS, VSO) each expressing essentially equivalent semantic information with different stylistic and pragmatic effects. Brown and Rivas (2011: 23)

As we subsequently confirm with an informal adult rating task, this flexibility extends to locative sentences. Thus children must learn that while *verter* ('pour') is ungrammatical in the *ground*-locative construction (4), it is grammatical – though rare – in a "shifted" *figure* locative construction that places the *ground* before the *figure* for pragmatic purposes, for example if the former is surprising or otherwise emphasized:

10. ¡La niña vertió en el zapato zumo! [The girl poured into the *shoe* juice!]

Conversely, while *llenar* ('to fill') is ungrammatical in the *figure*-locative construction (5), it is grammatical – though again rare – in a "shifted" *ground* locative construction that places the *figure* before the *ground* (again because the former is surprising or otherwise emphasized):

11. ¡La niña llenó con piedras el vaso! [The girl filled with *stones* the glass!]

Both types of shifted locative – although rare – are attested in corpus data, at least in written Spanish. For example, an informal search of the Corpus de Referencia del Español Actual (CREA) (Real Academia Española 2014) yielded the following examples (many of which illustrate another common pragmatic use of the shifted locative: moving a long or “heavy” Noun Phrase to the end of the sentence, presumably to reduce processing demands on the part of the listener):

**Shifted figure locatives with *verter*, ‘pour’**

- Es más, se atreve a verter en la opinión pública toda esa bazofia ideológica... [What is more, it dares to pour into public opinion all this ideological hogwash...]
- ... la burrada de verter en el mar 30.000 metros cúbicos de agua dulce... [... the stupidity of pouring into the sea 30,000 cubic meters of fresh water...]
- ... verter en él nuevos constructos culturales que aboguen... [... to pour into it new cultural constructs which advocate...]
- Éstos pueden verter en sus textos su propia subjetividad... [They can pour into their texts their own subjectivity...]
- ... discurso que tropezó con dificultades para verter en otro idioma aquella avalancha de palabras... [... speech experiencing difficulties to pour into another language that avalanche of words...]
- ... o de verter en ellos el veneno más doloroso y letal que... [... or pouring into them the most painful and deadly poison...]
- ... a verter en ellas los cubos, bacinillas y demás recipientes... [to pour into them the buckets, chamber pots and other containers...]
- ..., supo verter en sus dibujos la más agria intención. [..., he knew how to pour in his drawings the sourest intention.]
- A continuación verter en la olla el concentrado de tomate. [Then pour into the pot the tomato concentrate.]
- ..., verter en la asadera una taza de agua, o caldo y... [..., pour into the pan a cup of water or broth and...]

**Shifted ground locatives with *llenar*, ‘fill’**

- Todos queremos llenar con cenefas florales y altorrelieves el vacío... [We all want to fill with floral friezes and reliefs the void...]
- ... la sensación de ausentarse del escenario, de llenar con morcillas u oquedades algunos pasajes de... [... the feeling of absence from the stage, filling with blood sausages or cavities some passages...]
- ... hasta ahora en América del Sur, “no podríamos llenar con ellos ni una gorra de béisbol”. [... so far in South America, “we could not fill with them even a baseball cap”.]
- ..., a llenar con retórica este inmenso vacío de humanidad. [..., to fill with rhetoric this vast emptiness of humanity.]
- ..., sirvieron para llenar con el cuerpo y con el alma ese templo al que... [..., which served to fill with the body and soul that temple to which...]
- Luego siguieron, hasta llenar con tierra 200 bolsas de material y varios volquetes. [Then they followed, until they filled with soil 200 material bags and several tipper lorries.]
- ....., sólo para llenar con los chismes de sus estrellas el tacho de basura... [..., just to fill up with the gossip of his stars the garbage can...]
- Esteban Quiroz (Lluvia Editores) se ha propuesto llenar con libros el Cuarto del Rescate de Atahualpa,... [Esteban Quiroz (Lluvia Editores) intends to fill with books the Ransom of Atahualpa Room,...]
- .... en fin, conocedores de lo complicado que es llenar con sentido común los momentos de ocio en esta época del año,... [... in short, knowing how difficult it is to fill with common sense the leisure moments at this time of year,...]

- ... que al principio pronuncia la señora Smith para llenar con frases, casi sin sentido, el vacío que entre ella y su marido... [... at first pronounced by Mrs. Smith to fill with phrases, almost meaningless, the gap between her and her husband...]
- ... inmaduros y demás personas deseosas de llenar con “algo” ese vacío mundo de realidades... [...immature and other people eager to fill with “something” that empty world of realities...]
- ... para llenar con decoro sus bien compartidos espacios,... [... to fill with decorum their well-shared spaces,...]
- ... empezaron a traer excitantes cargas de oro para llenar con ellas un aposento,... [... they began to bring exciting loads of gold to fill with them a room,...]
- Una de ellas consiste en llenar con agua una botella de cristal transparente... [One of them consisting of filling with water a transparent glass bottle...]

Thus, all other things being equal, we might expect Spanish children to have more difficulty learning restrictions on the locative alternation than their English counterparts (other differences between the two languages are explored later in this introduction).

Notwithstanding any possible “delay” relative to English-speaking children with regard to this particular alternation, the aim of the present study is to investigate whether two mechanisms thought to be important for the restriction of argument structure generalizations – previously investigated almost exclusively in English – are also used by children learning Spanish.

Under Pinker’s (1989) semantic verb class hypothesis, learners form (partly with the aid of innate linking rules) classes of verbs with similar meanings that are restricted to either the figure-or ground-locative only, or that alternate between the two constructions. For example, in English, Pinker (1989) posits a figure-only class of verbs for which “a mass is enabled to move via the force of gravity” (e.g., *pour*, *drip*, *spill*, *dribble*), a ground-only class of verbs for which “a layer completely covers a surface” (e.g., *cover*, *coat*, *fill*, *line*) and an alternating class of verbs for which “force is imparted to a mass, causing ballistic motion in a specified direction along a trajectory” (e.g., *spray*, *sprinkle*, *splash*, *splatter*). A similar classification for Spanish locative verbs is outlined in Mayoral Hernández (2008). Children retreat from error only when non-alternating verbs have been definitively assigned to an appropriate class. This procedure can take considerable time, given that it requires children to learn a great deal about the fine-grained semantics of individual verbs; information that is not always straightforwardly observable from the child’s visual input (e.g., whether motion is “ballistic” and “caused” versus “enabled via gravity”).

Thus a prediction that follows from the semantic verb class hypothesis is that if Spanish-speakers are taught novel verbs that are semantically consistent with a figure-only semantic verb class (e.g., a novel equivalent of *verter* ‘pour’), they should show a significant preference for figure- over ground-locative uses in a grammaticality judgment task. Conversely, if they are taught novel verbs that are semantically consistent with a ground-only class (e.g., a novel equivalent of *llenar*, ‘fill’) they should show a significant preference for ground- over figure-locative uses. (In principle the account also predicts no preference for either figure- or ground-locative uses of novel alternating verbs. However, as we shall see shortly, devising novel alternating verbs proved not to be straightforward). On the assumption that these classes take a considerable time to develop, the semantic verb class hypothesis also predicts an interaction such that the above pattern should be observed for adults, but more weakly – or not at all – for young children.

Under statistical learning accounts (e.g., Braine and Brooks 1995; Goldberg 1995) children restrict their generalizations using a probabilistic competition-learning procedure. Each attested input token of – for example – *verter*, ‘pour’ – in a figure-locative construction (e.g., “Homer vertió agua en la taza”) contributes to an ever-strengthening probabilistic inference that this verb cannot be used in unattested constructions (e.g., the ground locative “\*Homer vertió la taza con agua”). The question of whether all uses of the relevant verb compete with the error (i.e., *entrenchment*; e.g., Braine and Brooks 1995; Stefanowitsch 2008), as opposed to only sentences with a similar meaning (i.e., *pre-emption*; e.g.,

Goldberg 1995; Goldberg 2011) is beyond the scope of the present study (though see Ambridge et al. (2012), for an attempt to distinguish these possibilities for the English locative constructions).

A prediction that follows from the statistical learning account is that – holding semantics as constant as possible – ungrammatical sentences will be rated as least acceptable with high frequency verbs, more acceptable with low frequency verbs, and most acceptable with novel<sup>1</sup> verbs (e. g., *\*Lisa llenó/forró/pebó papel en la caja* [*\*Lisa filled/lined/NOVEled paper into the box*]). A further prediction is that the magnitude of this effect will increase with age, as the statistical inference from absence increases over developmental time. A slight complication is that, in order to control for any general (dis)preferences that participants may show for particular verbs, scenes, characters etc., these predictions are usually tested not on raw ratings for ungrammatical sentences, but on difference scores that measure the extent of dispreference for ungrammatical versus grammatical sentences that are otherwise similar (e. g., the degree of dispreference for *\*Lisa llenó papel en la caja*, as compared to *Lisa llenó la caja de papel*)

Previous studies conducted with native learners of English have provided considerable support for both hypotheses. With regard to the semantic verb class hypothesis, both production and judgment studies have shown that if adults and children are taught novel verbs, they use their notional semantic class membership to determine the constructions in which they can and cannot appear (Gropen et al. 1989; Gropen et al. 1991a; Gropen et al. 1991b; Brooks and Tomasello 1999; Ambridge et al. 2008, Ambridge et al. 2009; Ambridge et al. 2011; Ambridge et al. 2012). With regard to the statistical learning hypothesis, many studies have observed the predicted negative correlation between verb frequency and the rated acceptability/production probability of overgeneralization errors, in judgment and production tasks respectively (Brooks and Tomasello 1999; Brooks et al. 1999; Brooks and Zizak 2002; Theakston 2004; Ambridge et al. 2008; Stefanowitsch 2008; Wonnacott et al. 2008; Ambridge et al. 2009; Goldberg 2011; Boyd and Goldberg 2011; Wonnacott 2011; Ambridge et al. 2012a; Ambridge et al., 2012b; Ambridge and Brandt 2013; Ambridge 2013; Ambridge et al. 2014).

Indeed, one previous English study (Bidgood et al. 2014) tested the same set of predictions outlined above for the present study with children aged 5–6 and 9–10 and adults. Consistent with the semantic verb class hypothesis, all age groups preferred figure- over ground-locative uses of novel *pour*-type (figure-only) verbs, with the two older groups also displaying the predicted preference for ground- over figure-locative uses of novel *fill*-type (ground-only verbs). Interestingly, adults (though not children) showed an unexpected preference for ground- over figure-locative uses of novel *spray*-type (“alternating”) verbs. Bidgood et al. (2014) suggested that this finding may have been a consequence of a “holism constraint”: The videos that accompanied the sentences to be rated showed successful, completed actions, for which the ground-locative is more natural (e. g., *Lisa loaded the wagon with hay* implies that the wagon was completely filled, while *Lisa loaded hay onto the wagon* does not).

Consistent with the statistical learning account, collapsing across all age-groups (as no interaction with age was found), participants’ dispreference for ungrammatical locative sentences – relative to equivalent grammatical locative sentences with the same verb – was greatest for high-frequency verbs (*pour*, *spill*, *cover*, *fill*), smaller for low-frequency verbs (*drip*, *dribble*, *coat*, *line*) and smallest for semantically-matched novel verbs.

If the semantic verb class and statistical learning hypotheses are to succeed as accounts of how children come to avoid argument structure overgeneralization errors, it is important that they apply not only to English, but to equivalent partial-productivity paradoxes that occur in other languages. However, to our knowledge, these hypotheses have only been tested with data from English speakers. As a preliminary

<sup>1</sup> Indeed, under a statistical learning account that incorporated no role for verb semantics, all novel verbs would be predicted to be equally acceptable in both locative constructions. However, because, in practice, most statistical learning accounts in this domain also posit at least some role for verb semantics, we interpret them as predicting that “ungrammatical” uses of novel verbs (based on their semantics) will be merely *more* acceptable than equivalent uses of high- or low-frequency familiar verbs. We thank the area editor, Bhuvana Narasimhan, for raising this point.



investigation of the cross-linguistic viability of these hypotheses, the present study sought to replicate the English study described above (Bidgood et al. 2014) in Spanish.

Assuming that these mechanisms operate in a similar way cross-linguistically, the prediction of the semantic verb class hypothesis is that participants taught novel verbs whose semantics are consistent with a figure-locative-only class will show a significant preference for figure- over ground- locative uses; and vice-versa for novel semantically ground-only verbs. The prediction of the statistical learning hypothesis is that the magnitude of this preference will be greatest for high frequency verbs, smaller for low frequency verbs and smallest for novel verbs. Both accounts predict developmental effects, such that the magnitude of each will increase with age as (a) semantic verb classes are formed and refined and (b) the statistical inference is strengthened by repeated exposure to the relevant verb in grammatical sentences that compete with the error.

Finally, given the greater flexibility of Spanish with regard to word order and the relative acceptability of “shifted” locatives (e. g., *La niña vertió en el vaso zumo* [The girl poured into the glass juice]), we might expect Spanish children to show a delay relative to English children with regard to acquisition of the restrictions on figure- and ground- locatives; structures which are distinguished primarily by the ordering of the post-verbal noun phrases. That is, we might expect Spanish children *not* to show semantic verb class and statistical learning effects that are seen amongst English children of a comparable age.

Another reason to expect a delay relative to English children is that the Spanish locative alternation is arguably more idiosyncratic. For example, data presented in Hunter (2008), summarized in Table 1, suggest that while, in English, all *fill*-type and *pour*-type verbs are ground-only and figure-only respectively, in Spanish, 5/18 *fill*-type verbs and 1/9 *pour*-type verbs buck the trend. Conversely, while all English *load*-type verbs alternate, Spanish *load*-type verbs may be figure only (8/14) ground only (3/14) or alternating (3/14). Caution must be exercised here, as the designations *fill*-type, *pour*-type and *load*-type were formed on the basis of English, and so are by definition exceptionless in that language. Thus, it may be that Spanish is not more idiosyncratic than English, but just draws its semantic classes slightly differently. However, to the extent to which it is possible to posit verb type distinctions that are valid cross-linguistically, the available evidence suggests that the link between locative semantics and syntax may be at least somewhat less regular in Spanish than English. If this is indeed the case, then the prediction that follows is that any delay shown by Spanish children relative to their English counterparts may be greater with regard to the effects of semantic verb class formation than statistical learning.

**Table 1:** Breakdown of alternating, figure-only and ground-only verbs in English and Spanish (a) by verb-type (from Hunter 2008) and (b) overall (from Pinker 1989).

	English			Spanish		
	Alt	Fig-only	Grd-only	Alt	Fig-only	Grd-only
<i>Spray</i> type	6	0	0	6	0	0
<i>Load</i> type	11	0	0	3	8	3
<i>Pour</i> type	0	7	0	1	8	0
<i>Coil</i> type	0	8	0	0	6	3
<i>Fill</i> type	0	0	20	5	0	13
Total	17	15	20	15	22	19
Percentage	32.7	28.8	38.5	26.8	39.3	33.9
Pinker (1989)*	33	33	76	44	44	54
Percentage	23.2	23.2	53.5	31.0	31.0	38.0

Note: \*The Spanish counts were obtained simply by finding the nearest translational equivalent of each verb listed by Pinker (1989), and classifying each as figure-only, ground-only or alternating on the basis of our own intuitions (also the method used by Pinker).

# 1 Method

## 1.1 Ethics statement

The study was approved by the research ethics committee at Universidad Complutense de Madrid. Children gave verbal consent, whilst informed written consent was obtained from parents, as well as adult participants.

## 1.2 Participants

Participants were 33 children aged 6–7 (range: 6;6–7;4,  $M = 7;0$ ), 33 aged 10–11 (range: 10;0–13;0,  $M = 11;7$ ) and 33 adults (University students, range: 18;6–44;7,  $M = 22;9$ ). Given the additional complications in the acquisition of the Spanish locative constructions discussed above, we decided to recruit slightly older children than those who participated in the English study of Bidgood et al. (5;11 and 9;11).

## 1.3 Design, materials and procedure

The study used a  $3 \times 2 \times 3 \times 3 \times 2$  (age  $\times$  counterbalance version  $\times$  semantic verb class  $\times$  frequency  $\times$  sentence type) mixed design, with between-subjects variables of age-group (6–7, 10–11, 18–22) and counterbalance version (two groups, reflecting the pairing of novel verb forms with meanings; in no analysis was this variable associated with any main effects or interactions; thus it will be excluded from subsequent discussion). The within-subjects variables were semantic verb class (*fill*-verbs, *spray/splash*-verbs and *pour*-verbs; designed to be ground-only, alternating and figure-only respectively), frequency (high, low, novel) and sentence type (figure/ground-locative). In order to maximize comparability across the two studies, we used equivalent verb classes to the English study of Bidgood et al. (2014). While, according to both Hunter (2008) and our own intuitions, the classes show similar behaviour across English and Spanish, we have already seen some evidence that there may be some small differences (e. g., *fill*-verbs and *spray*-verbs might be ground-preferring and figure-preferring to a different extent in the two languages; see Table 1).

Verb frequency information was taken from the Corpus de Referencia del Español Actual (CREA) (Real Academia Española 2014), a 200-million word corpus mainly derived from books and newspapers, and the SUBTLEX-ESP subtitle corpus (Cuetos et al. 2011), a 41-million word corpus derived from modern films and TV series (1990–2009) and validated using reaction-time tasks (which are highly sensitive to lexical frequency). Although, in principle, it would have been preferable to use a corpus of child-directed speech, the majority of verbs used in the present study are too infrequent to be found in such corpora. We supplemented the written CREA corpus with the spoken subtitle corpus, because spoken language is more representative of the majority of the linguistic input of – certainly – the youngest group, and – in all probability – the two older groups too. Verbs were selected such that each high frequency verb was always of greater frequency than the relevant paired low frequency verb in both corpora.

As far as possible, verbs were chosen from the semantic classes outlined by Hunter (2008) and Mayoral Hernández (2008),<sup>2</sup> though, in some cases, it was necessary to use additional verbs that are not listed in these sources, based on the intuitions of the first author (a native speaker of standard Castilian Spanish). Crossing the within-subjects variables yielded 18 cells of the design. Two items – sentences using the relevant verb (in past tense form) – were created for each cell, as shown in Table 2. Each sentence was paired with an animation depicting the event described (the same animations used in the study of Bidgood et al. 2014).

<sup>2</sup> It was not possible to use data from this source in Table 1, as Hernández (2008) lists only examples of each class rather than numerical counts, and does not attempt to equate verbs across languages.



Table 2: Stimuli and properties.

Verb class	Freq.	English verb (Bidgood et al. 2014)>	Spanish verb* – present study	Verb classification (Hernández 2008)	Frequency (SUBTLEX-ESP)		Frequency (CREA)		Sentence type	Sentence	English translation
					Past	Pres	Past	Pres			
<i>Fill verbs</i> (ground- only)	High	Cover	cubrir	Ground-only	100	511	767	2550	*Figure	*Bart cubrió barro en Lisa	*Bart covered mud onto Lisa
			(cover)						Ground	Bart cubrió a Lisa con barro	Bart covered Lisa with mud
	Low	Coat	ensuciar	Ground-only	21	37	19	86	*Figure	*Bart ensució barro en Lisa	*Bart coated mud onto Lisa
			(soil, dirty)						Ground	Bart ensució a Lisa con barro	Bart coated Lisa with mud
Novel	bledge/ blafe		lipar/madar	NA	NA	NA	NA	NA	*Figure	*Bart lipó/madó barro en Lisa	*Bart bredged mud onto Lisa
									Ground	Ground Bart lipó/madó a Lisa con barro	Bart bredged Lisa with mud
High	Fill		llenar	Ground-only	185	2198	1398	7489	*Figure	*Lisa llenó papel en la caja	*Lisa filled paper into the box
			(fill)						Ground	Lisa llenó la caja con papel	Lisa filled the box with paper
Low	Line		forrar	Ground-only	5	6	15	25	*Figure	*Lisa forró papel en la caja	*Lisa lined paper into the box
			(line, cover)						Ground	Lisa forró la caja con papel	Lisa lined the box with paper
Novel	chool/ tesh		pebar/nupar	NA	NA	NA	NA	NA	*Figure	*Lisa pebó/nupó papel en la caja	*Lisa chooled paper into the box
									Ground	Lisa pebó/nupó la caja con papel	Lisa chooled the box with paper

<b>Spray/splash verbs</b> (alternating?)	High	Spray	regar	Not listed	13	9	78	162	Figure	Lisa regó agua en las rosas	Lisa sprayed water onto the roses
			(water, irrigate)						Ground	Lisa regó las rosas con agua	Lisa sprayed the roses with water
	Low	Sprinkle	chispear		0	2	1	10	Figure	Lisa chispeó agua en las rosas	Lisa sprinkled water onto the roses
			(sparkle, spark)	Alternating					Ground	Lisa chispeó las rosas con agua	Lisa sprinkled the roses with water
	Novel	tesh/ bredge	dosar/dafar	NA	NA	NA	NA	NA	Figure	Lisa dosó/dafó agua en las rosas	Lisa teshed water onto the roses
									Ground	Lisa dosó/dafó las rosas con agua	Lisa teshed the roses with water
	High	Splash	salpicar	Alternating	16	24	81	142	Figure	Homer salpicó agua en Marge	Homer splashed water onto Marge
			(spatter, splash, sprinkle)						Ground	Homer salpicó a Marge con agua	Homer splashed Marge with water
	Low	Spatter	gotear	Not listed	2	46	4	45	Figure	Homer goteó agua en Marge	Homer spattered water onto Marge
			(drip, leak)						Ground	Homer goteó a Marge con agua	Homer spattered Marge with water
<b>Pour verbs</b> (figure-only)	Novel	dape/ nace	nogar/semar/	NA	NA	NA	NA	NA	Figure	Homer semó/nogó agua en Marge	Homer daped water onto Marge
									Ground	Homer semó/nogó a Marge con agua	Homer daped Marge with water
	High	Pour	añadir	Not listed	35	60	9035	6181	Figure	Homer añadió agua en la taza	Homer poured water into the cup
			(add)						*Ground	*Homer añadió la taza con agua	*Homer poured the cup with water
	Low	Drip	verter	Figure-only	9	24	136	461	Figure	Homer vertió agua en la taza	Homer dripped water into the cup
			(pour, spill)						*Ground	*Homer vertió la taza con agua	*Homer dripped the cup with water

(continued)

Table 2: (continued)

Verb class	Freq.	English verb (Bidgood et al. 2014)>	Spanish verb* – present study	Verb classification (Hernández 2008)	Frequency (SUBTLEX-ESP)		Frequency (CREA)		Sentence type	Sentence	English translation
					Past	Pres	Past	Pres			
Novel	nace/ dape		zizar/pofar	NA	NA	NA	NA	NA	Figure	Homer zijó/pofó agua en la taza	Homer naced water into the cup
									*Ground	*Homer zijó/pofó la taza con agua	*Homer naced the cup with water
High	Spill		tirar	Not listed	596	1144	1568	2298	Figure	Marge tiró zumo en la alfombra	Marge spilt juice onto the rug
			(throw, hurl, toss)						*Ground	*Marge tiró la alfombra con zumo	*Marge spilt the rug with juice
Low	Dribble		esparcir	Not listed	33	39	69	119	Figure	Marge esparció zumo en la alfombra	Marge dribbled juice onto the rug
			(scatter, spread)						*Ground	*Marge esparció la alfombra con zumo	*Marge dribbled the rug with juice
Novel	blafe/ chool		tudar/chobar	NA	NA	NA	NA	NA	Figure	Marge tudó/chobó zumo en la alfombra	Marge blafed juice onto the rug
									*Ground	*Marge tudó/chobó la alfombra con zumo	*Marge blafed the rug with juice

Note: Note that for novel verbs, ungrammaticality (indicated by an asterisk) is determined solely on the basis of verb semantics (since, unlike for familiar verbs, attested usage of course plays no role); see Footnote 1.

Due to the close equivalence between the English semantic verb classes used by Bidgood et al. (2014) and the Spanish classes used in the present study (see Hunter 2008, and discussion above), we were able to use the novel verb meanings, and accompanying animations, from this previous study (see Appendix A). Thus, as in Bidgood et al. (2014), each novel verb was given a meaning that was consistent with the semantic class, but subtly different from the meanings of the familiar verbs in that class. Before the study began, and before each trial with a novel verb, participants were shown a training animation to teach/remind them of the meaning of that verb. These training animations were presented along with neutral audio (e.g., *Mira lo que X está haciendo. Se llama X-ar* [= Look what X is doing. It's called VERBing]), and were followed by a brief verbal definition (see Appendix A for details).

Participants provided grammaticality judgment ratings via a five-point “smiley face” scale (see Ambridge et al. 2008; Bidgood et al. 2014 for details). In brief, children select either a red counter, indicating broadly ungrammatical, or a green counter, indicating broadly grammatical, before placing the counter on the scale to indicate the degree of perceived (un)grammaticality. Adults simply tick the scale directly. Warm-up sentences with accompanying animations (see Appendix B for details) were used to train participants in the appropriate use of the scale; the experimenter gave feedback for these warm-up trials only. Following the warm-up, participants completed the full set of test trials ( $N = 36$ ) in pseudo-random order, such that the same verb never occurred in two consecutive sentences.

## 2 Results

The mean ratings for each sentence are given in Table 3.

### 2.1 Preliminary analysis

Given that this is the first study of its type in Spanish, it was first necessary to conduct a preliminary analysis on the *familiar verbs only*, in order to check that we were successful in our aim of selecting verbs that are indeed viewed as *figure-only*, *ground-only* and *alternating* respectively by adult native speakers. This analysis also allows us to check that children were using the scale as intended; i.e., that they were capable of producing reasonably adultlike judgments for familiar verbs. A  $3 \times 2 \times 2 \times 2$  (age  $\times$  verb class  $\times$  frequency  $\times$  sentence type) ANOVA<sup>3</sup> yielded a significant 4-way interaction ( $F_{4,192} = 4.95$ ,  $p < 0.001$ ), see Table 4 for details.

Post hoc tests conducted on this interaction (see Table 4 for  $p$  values) revealed that, with a single exception, all age groups showed the predicted pattern for the non-alternating verbs. That is, all age groups showed a significant preference for ground over figure uses of the ground-only familiar verbs (*cubrir* ‘cover’, *ensuciar* ‘soil, dirty’, *llenar* ‘fill’, *forrar* ‘line, cover’) and for figure over ground uses of the figure-only familiar verbs (*añadir* ‘add’, *verter* ‘pour, spill’, *tirar* ‘throw, hurl, toss’, *esparcir* ‘scatter’). The one exception to this pattern was the low frequency figure-only verbs for the youngest children. Inspection of the individual sentence ratings (Table 3) indicates that the source of this exception is the very low frequency verb *esparcir* ‘scatter’, for which the figure and ground sentences received equal ratings (sentence ratings for the other, *verter* ‘pour, spill’, were in the predicted direction).

These preliminary findings are important, as they demonstrate (a) that all age groups are capable of performing the rating task as intended and (b) that the verbs and classes selected to be non-alternating (i.e., figure-only and ground-only) were indeed treated as such by adults, older children and – with the

<sup>3</sup> All ANOVAs were conducted by subjects rather than by items. Although, in principle, it would have been preferable to also conduct a by-items analysis (or to use mixed-effects models), this is not possible, given that we used only two items per cell of the design.

Table 3: Mean ratings for all sentences.

Verb class	Freq	Verb	S type	Sentence	All participants		Age 6–7		Age 10–11		Adults	
					M	SD	M	SD	M	SD	M	SD
Fill verbs (ground-only)												
	High	cubrir (cover)	*Figure	*Bart cubrió barro en Lisa	2.76	1.46	3.48	1.50	2.73	1.38	2.06	1.17
	Low	ensuciar	Ground	Bart cubrió a Lisa con barro	4.39	1.26	3.85	1.54	4.58	1.03	4.76	0.97
			*Figure	*Bart ensució barro en Lisa	2.22	1.45	2.85	1.70	2.06	1.14	1.76	1.25
	Novel	liparmadar (soil, dirty)	Ground	Bart ensució a Lisa con barro	4.25	1.36	3.79	1.60	4.21	1.36	4.76	0.87
			*Figure	*Bart lipó/madó barro en Lisa	2.66	1.55	3.00	1.64	2.70	1.49	2.27	1.48
	High	llenar	Ground	Ground Bart lipó/madó a Lisa con barro	3.22	1.60	3.33	1.73	3.27	1.53	3.06	1.58
			*Figure	*Lisa llenó papel en la caja	2.72	1.48	3.82	1.38	2.39	1.25	1.94	1.12
	Low	forrar	Ground	Lisa llenó la caja con papel	4.72	0.78	4.76	0.61	4.45	1.15	4.94	0.24
			*Figure	*Lisa forró papel en la caja	2.98	1.42	3.91	1.21	2.91	1.18	2.12	1.29
	Novel	pebarnupar/ (line, cover)	Ground	Lisa forró la caja con papel	4.35	1.08	4.36	0.99	3.94	1.22	4.76	0.87
			*Figure	*Lisa pebó/nupó papel en la caja	3.06	1.49	3.12	1.56	3.15	1.42	2.91	1.53
		madardosar	Ground	Lisa pebó/nupó la caja con papel	3.30	1.47	4.12	1.29	2.88	1.29	2.91	1.49
Spray/splash verbs (alternating?)												
	High	regar (water, irrigate)	Figure	Lisa regó agua en las rosas	3.43	1.58	4.33	1.11	3.48	1.44	2.48	1.60
	Low	chispear	Ground	Lisa regó las rosas con agua	4.80	0.57	4.82	0.73	4.70	0.59	4.88	0.33
			Figure	Lisa chispeó agua en las rosas	3.77	1.33	4.30	1.13	3.67	1.38	3.33	1.31
	Novel	madardosar/ (sparkle, spark)	Ground	Lisa chispeó las rosas con agua	3.34	1.44	4.06	1.22	3.15	1.18	2.82	1.61
			Figure	Lisa dosó/dafó agua en las rosas	2.86	1.56	3.39	1.54	2.85	1.44	2.33	1.55
	High	liparmadar	Ground	Lisa dosó/dafó las rosas con agua	3.28	1.44	3.33	1.61	3.18	1.31	3.33	1.43
		salpicar	Figure	Homer salpicó agua en Marge	3.11	1.24	2.82	1.49	3.36	1.17	3.15	0.97
	Low	gotear (splash)	Ground	Homer salpicó a Marge con agua	4.31	1.21	4.00	1.54	4.21	1.17	4.73	0.67
			Figure	Homer goteó agua en Marge	2.57	1.33	2.61	1.56	2.73	1.13	2.36	1.27
	Novel	liparmadar (drip, leak)	Ground	Homer goteó a Marge con agua	3.21	1.36	3.94	1.17	3.15	1.33	2.55	1.25
			Figure	Homer semó/nogó agua en Marge	2.71	1.42	3.39	1.43	2.94	1.30	1.79	0.99
		dosartilpar	Ground	Homer semó/nogó a Marge con agua	3.27	1.41	3.88	1.43	3.12	1.27	2.82	1.36

<b>Pour verbs</b> (figure-only)	High	añadir (add)	Figure	Homer añadió agua en la taza	4.44	0.96	4.45	1.03	4.15	1.09	4.73	0.63
	Low	verter	*Ground	*Homer añadió la taza con agua	3.21	1.53	4.39	1.12	2.85	1.48	2.39	1.20
	Novel	(pour, spill)	Figure	Homer vertió agua en la taza	3.83	1.35	3.52	1.37	3.48	1.30	4.48	1.15
	High	dosarlipar/ nogarsemar/ tirar	*Ground	*Homer vertió la taza con agua	3.09	1.41	4.12	1.22	2.64	1.25	2.52	1.20
	Low	(throw, hurl, toss)	Figure	Homer zifó/pofó agua en la taza	3.34	1.55	3.61	1.50	2.97	1.45	3.45	1.66
	Novel	semarnogar/ pebarnupar	*Ground	*Homer zifó/pofó la taza con agua	3.01	1.54	3.64	1.52	2.91	1.35	2.48	1.54
	High		Figure	Marge tiró zumo en la alfombra	4.40	1.17	3.94	1.52	4.42	1.06	4.85	0.57
	Low		*Ground	*Marge tiró la alfombra con zumo	2.15	1.49	2.82	1.65	2.00	1.48	1.64	1.06
	Novel	esparcir (scatter, spread)	Figure	Marge esparció zumo en la alfombra	3.90	1.37	3.27	1.64	4.09	1.18	4.33	0.99
	High	semarnogar/ pebarnupar	*Ground	*Marge esparció la alfombra con zumo	2.56	1.44	3.27	1.42	2.52	1.33	1.88	1.24
	Low		Figure	Marge tudó/chobó zumo en la alfombra	2.80	1.52	2.97	1.53	2.15	1.20	3.27	1.61
	Novel		*Ground	*Marge tudó/chobó la alfombra con zumo	2.88	1.52	3.06	1.69	2.85	1.48	2.73	1.40

Note: Note that for novel verbs, ungrammaticality (indicated by an asterisk) is determined solely on the basis of verb semantics (since, unlike for familiar verbs, attested usage of course plays no role); see Footnote 1.



Table 4: Mean ratings for sentences with familiar verbs.

Age	Verb class	Freq.	Stype	Mean	Std. error	95 CI Min	95 CI Max	p
6–7	<b>Fill verbs</b> (ground only)	High	Fig	3.65	0.18	3.29	4.01	0.01
			Grd	4.30	0.13	4.06	4.55	
		Low	Fig	3.38	0.17	3.05	3.71	0.00
			Grd	4.08	0.14	3.79	4.36	
	<b>Spray/splash verbs</b> (alternating?)	High	Fig	3.58	0.19	3.21	3.95	<0.0001
			Grd	4.41	0.11	4.19	4.63	
		Low	Fig	3.46	0.18	3.10	3.81	0.01
			Grd	4.00	0.18	3.64	4.36	
	<b>Pour verbs</b> (figure only)	High	Fig	4.20	0.15	3.90	4.49	0.00
			Grd	3.61	0.17	3.27	3.95	
		Low	Fig	3.39	0.16	3.07	3.72	0.15
			Grd	3.70	0.16	3.39	4.01	
10–11	<b>Fill verbs</b> (ground only)	High	Fig	2.56	0.18	2.20	2.92	<0.0001
			Grd	4.52	0.13	4.27	4.76	
		Low	Fig	2.49	0.17	2.16	2.81	<0.0001
			Grd	4.08	0.14	3.79	4.36	
	<b>Spray/splash verbs</b> (alternating?)	High	Fig	3.42	0.19	3.05	3.79	<0.0001
			Grd	4.46	0.11	4.23	4.68	
		Low	Fig	3.20	0.18	2.85	3.55	0.81
			Grd	3.15	0.18	2.79	3.51	
	<b>Pour verbs</b> (figure only)	High	Fig	4.29	0.15	3.99	4.58	<0.0001
			Grd	2.42	0.17	2.08	2.77	
		Low	Fig	3.79	0.16	3.47	4.11	<0.0001
			Grd	2.58	0.16	2.26	2.89	
Adults	<b>Fill verbs</b> (ground only)	High	Fig	2.00	0.18	1.64	2.36	<0.0001
			Grd	4.85	0.13	4.60	5.10	
		Low	Fig	1.94	0.17	1.61	2.27	<0.0001
			Grd	4.76	0.14	4.47	5.04	
	<b>Spray/splash verbs</b> (alternating?)	High	Fig	2.82	0.19	2.45	3.19	<0.0001
			Grd	4.80	0.11	4.58	5.03	
		Low	Fig	2.85	0.18	2.50	3.20	0.39
			Grd	2.68	0.18	2.32	3.04	
	<b>Pour verbs</b> (figure only)	High	Fig	4.79	0.15	4.49	5.08	<0.0001
			Grd	2.02	0.17	1.68	2.36	
		Low	Fig	4.41	0.16	4.09	4.73	<0.0001
			Grd	2.20	0.16	1.89	2.51	

exception of the single verb *esparcir* – younger children, and are thus suitable for use in the subsequent tests of the semantic verb class and statistical learning hypotheses.

The same cannot be said, however, for the verbs and classes that we selected to be “alternating” (i. e., equally acceptable in the figure and ground locative). For the high frequency “alternating” verbs (*regar* ‘water, irrigate’ and *salpicar* ‘spatter, splash, sprinkle’) all groups showed a preference for ground over figure uses. A similar pattern was shown by English-speaking adults in the study of Bidgood et al. (2014); a finding that these authors attributed to the holism constraint: As discussed in the introduction, when an action is successful and complete – as in the accompanying animations – a ground-locative is more natural than a figure-locative. For the low frequency verbs (*chispear* ‘sparkle, spark’ and *gotear* ‘drip, leak’), the younger children again showed a ground preference, with the two older groups showing the predicted pattern of no preference for either figure or ground uses.

In summary, while we were successful in selecting non-alternating (ground- and figure-only) semantic verb classes, we did not succeed in selecting an unambiguously alternating semantic class: some verbs seem to alternate, others show a ground preference (this may be a consequence, at least in part, of the fact

that Spanish verb classes may be somewhat more idiosyncratic than English; Hunter 2008). Thus the subsequent investigation of the semantic verb class hypothesis focuses on the non-alternating classes only (though, for completeness, we report all results).

## 2.2 Semantic verb class hypothesis

The semantic verb class hypothesis predicts that participants will use the notional semantic class of novel verbs to determine the constructions in which they can and cannot appear. That is, it predicts that participants will prefer figure- over ground-locative uses of novel *pour*-type (figure-only) verbs and ground- over figure-locative uses of novel *fill*-type (ground-only) verbs. Given that we apparently did not manage to select a class of truly alternating verbs (see the familiar-verbs analysis above), the hypothesis does not make any straightforward predictions regarding the novel *spray/splash* verbs. (If anything, we may expect to see a ground- over figure-locative preference, given that this was the pattern observed for some of the familiar verbs).

A  $3 \times 3 \times 2$  (age  $\times$  verb class  $\times$  sentence type) ANOVA conducted on the ratings for novel verbs yielded a 3-way interaction ( $F_{4,192} = 7.02$ ,  $p < 0.001$ ), see Table 5 for details. Post hoc tests conducted on this interaction (see Table 5 for  $p$  values) revealed that adults displayed the predicted preference for figure- over ground-locative uses of novel figure-only (*pour*-type) verbs, and – marginally ( $p = 0.07$ ) – for ground- over figure-locative uses of novel ground-only (*fill*-type) verbs. Adults also showed a preference for ground over figure “alternating” verbs, though, as discussed above, this finding is difficult to interpret. Thus while these findings provide evidence for the psychological reality of figure-only classes amongst Spanish speakers, the evidence for ground-only classes is much weaker (i. e.,  $p = 0.07$ ). That said, the findings for the “alternating” verbs raises the possibility that Spanish does exhibit some ground-only semantic classes, but we have not succeeded in correctly identifying them.

**Table 5:** Mean ratings for sentences with novel verbs only.

Age	Verb class	Stype	Mean	Std. error	95 CI min.	95 CI max.	$p$
6–7	<b>Fill verbs</b>	Fig	3.06	0.23	2.61	3.51	0.002
	(ground only)	Grd	3.73	0.22	3.30	4.16	
	<b>Spray/splash verbs</b>	Fig	3.39	0.20	3.01	3.78	0.297
	(alternating?)	Grd	3.61	0.20	3.21	4.00	
	<b>Pour verbs</b>	Fig	3.29	0.22	2.86	3.72	0.777
	(figure only)	Grd	3.35	0.22	2.92	3.78	
10–11	<b>Fill verbs</b>	Fig	2.92	0.23	2.48	3.37	0.477
	(ground only)	Grd	3.08	0.22	2.65	3.51	
	<b>Spray/splash verbs</b>	Fig	2.89	0.20	2.51	3.28	0.206
	(alternating?)	Grd	3.15	0.20	2.76	3.55	
	<b>Pour verbs</b>	Fig	2.56	0.22	2.13	2.99	0.139
	(figure only)	Grd	2.88	0.22	2.45	3.31	
Adults	<b>Fill verbs</b>	Fig	2.59	0.23	2.14	3.04	0.066
	(ground only)	Grd	2.99	0.22	2.56	3.42	
	<b>Spray/splash verbs</b>	Fig	2.06	0.20	1.67	2.45	<0.0001
	(alternating?)	Grd	3.08	0.20	2.68	3.47	
	<b>Pour verbs</b>	Fig	3.36	0.22	2.93	3.80	0.001
	(figure only)	Grd	2.61	0.22	2.18	3.04	

The older children did not show the predicted preference for either figure over ground uses of figure-only verbs or vice versa, suggesting that whatever semantic classes are psychologically real for adults are not yet in place even by age 10–11 (neither was any effect observed for the novel “alternating” verbs). In contrast, recall that the English-speaking 10-year olds studied by Bidgood et al. (2014) showed adultlike performance with novel verbs.

Given this null finding, it is surprising that the younger Spanish children did display the predicted preference for ground- over figure-locative uses of novel ground-only (*fill*-type) verbs; though not for figure-over ground-locative uses for novel figure-only (*pour*-type verbs). This reverses the pattern shown by the youngest English speaking children, who showed the predicted pattern for novel *pour*-type verbs, but not novel *fill*-type verbs. Possible explanations for the discrepancy between the Spanish 6–7 year olds and (a) the English 5–6 year olds and (b) the Spanish 9–10 year olds will be explored in the discussion.

In summary, the findings of the present study suggest that the semantic verb class hypothesis may offer a plausible account of the adult end-state (though work remains to be done to delineate these classes more precisely), but we do not have convincing evidence to suggest that these classes have been formed even by Spanish-speaking children as old as 10–11 years.

## 2.3 Statistical learning hypothesis

Following Bidgood et al. (2014) and Ambridge et al. (2008) our test of the statistical learning hypothesis used not raw scores, but *difference scores*, calculated by subtracting the rating for each ungrammatical sentence from the rating for its grammatical equivalent, on a participant-by-participant basis. For example, if a particular participant gave the following ratings (on the 5-point scale) for sentences with *cubrir*, ‘cover’

\*Bart cubrió barro en Lisa, ‘Bart covered mud onto Lisa’: 2/5

Bart cubrió a Lisa con barro, ‘Bart covered Lisa with mud’ 5/5

then this participant’s difference score for *cubrir* would be 3 (i. e., 5–2). Thus possible difference scores range between 0 and 4 (i. e., 5–1). The use of difference scores is necessary because participants generally show higher baseline preferences for sentences that contain higher frequency than lower frequency verbs, even when all sentences are fully grammatical (see Ambridge et al. 2008, for discussion). The use of these difference – or *dispreference-for-ungrammatical-use* – scores allows us to assess the effect of frequency while controlling for this potential confound, as well as others such as a general (dis)preference for particular characters, scenes etc. The prediction of the statistical learning hypothesis is that difference scores will be greatest for high frequency verbs, smaller for low frequency verbs, and smallest for novel verbs (as observed by Bidgood et al. 2014, for English).

A  $3 \times 2 \times 3$  (age  $\times$  verb class  $\times$  frequency) ANOVA conducted on the difference scores yielded an interaction of frequency by age ( $F_{4,192} = 20.02$ ,  $p < 0.001$ ), but no three-way interaction; see Table 6 for details. Post hoc tests conducted on this interaction (see Table 6 for  $p$  values) revealed that the adults and older children

**Table 6:** Mean difference (dispreference for grammatical use) scores for high frequency, low frequency and novel verbs.

Age	Frequency	Mean	Std. error	95 CI min.	95 CI max.	Comparison	$p$
6–7	High	0.62	0.18	0.27	0.98	High vs low	<b>0.005</b>
	Low	0.20	0.17	-0.14	0.53	High vs novel	0.151
	Novel	0.30	0.15	0.01	0.59	Low vs novel	0.607
10–11	High	1.91	0.18	1.55	2.27	High vs low	<b>0.001</b>
	Low	1.40	0.17	1.07	1.74	High vs novel	<b>&lt;0.001</b>
	Novel	-0.08	0.15	-0.37	0.21	Low vs novel	<b>&lt;0.001</b>
Adults	High	2.81	0.18	2.45	3.17	High vs low	0.05
	Low	2.52	0.17	2.18	2.85	High vs novel	<b>&lt;0.001</b>
	Novel	0.58	0.15	0.29	0.87	Low vs novel	<b>&lt;0.001</b>
All participants (main effect)	High	1.78	0.10	1.58	1.99	High vs low	<b>&lt;0.01</b>
	Low	1.37	0.10	1.18	1.56	High vs novel	<b>&lt;0.01</b>
	Novel	0.27	0.08	0.10	0.43	Low vs novel	<b>&lt;0.01</b>

displayed exactly the predicted pattern, with all three comparisons significant. For the younger children, only the comparison between high and low frequency verbs was significant, in the predicted direction. Indeed, the low frequency verbs were treated very similarly to the novel verbs, perhaps because at least some of the lower frequency verbs are effectively novel for at least some of the younger children.

Given the presence of this age  $\times$  frequency interaction, it is debatable as to whether the large main effect of frequency that was also observed ( $F_{2,192} = 98.24$ ,  $p < 0.001$ ) is interpretable (e. g., Nelder and Lane 1995; Langsrud 2003; Scholer 2012). Nevertheless, post hoc tests conducted on this main effect (see Table 6) revealed that all comparisons were significant in the predicted direction. Thus, to the extent that this main effect is interpretable, it constitutes further evidence of the predicted three-step frequency effect.

In summary, although possible floor effects for low frequency verbs may be at play for the youngest group – who treated low frequency familiar verbs like novel verbs – overall, the findings of the present study suggest clear evidence of a frequency-based statistical learning effect for all age groups.

### 3 Discussion

The aim of the present study was to assess the extent to which two mechanisms thought to aid in the retreat from overgeneralization for English locative constructions – the formation of semantic verb classes and statistical learning (*entrenchment/pre-emption*) – apply to native learners of Spanish. To that end, we conducted a modified replication of the English study of Bidgood et al. (2014), which found evidence for both semantic and statistical learning effects for all three age-groups studied.

With regard to the semantic verb class hypothesis, the present findings suggest that something like the verb classes proposed by Pinker (1989) are psychologically real for Spanish speaking adults, who rejected ground-locative uses of novel verbs designed to be semantically consistent with figure-only semantic classes, and – marginally ( $p = 0.07$ ) – vice versa. (The results for “alternating” verbs were not interpretable, given that we apparently did not succeed in identifying unambiguously alternating classes). However, unlike English speaking children, who showed such effects as young as 5–6, Spanish children showed little evidence of having acquired these semantic constraints, even by age 10–11.

Why should the process of semantic verb class formation take longer for learners of Spanish than English? In the introduction, we raised two possibilities. The first is that Spanish word order is more flexible than English word order, both in general and with respect to the locative construction. In order to verify this intuition, we conducted a web-based judgment study with 332 adult native speakers of Spanish, who rated canonical and shifted locatives using the verbs *llenar*, ‘fill’ and *verter*, ‘pour’, using a scale of 1–10 (higher scores = greater acceptability). The mean ratings are shown in Table 7.

**Table 7:** Mean ratings for canonical and shifted locatives.

	Mean	SE
Lisa llenó papel en la caja	1.38	0.07
Lisa llenó en la caja papel	1.68	0.10
<b>Lisa llenó con papel la caja</b>	<b>8.78</b>	<b>0.12</b>
Lisa llenó la caja con papel	9.27	0.10
Homer vertió zumo en el suelo	7.65	0.17
<b>Bart vertió en el suelo zumo</b>	<b>7.48</b>	<b>0.16</b>
Marge vertió el suelo con el zumo	1.48	0.08
Bart vertió con el zumo el suelo	1.89	0.12

Note: The literal English translations of these sentences are as follows: Lisa lined... paper into the box/into the box paper/with paper the box/the box with paper. Homer/Bart/Marge poured... juice onto the floor/onto the floor juice/the floor with juice/with juice the floor. Shift locatives rated as acceptable are highlighted with bold letters.

The important point for our purposes is that although the shifted locatives (*Lisa llenó con papel la caja*, ‘Lisa lined with paper the box’ and *Bart vertió en el suelo zumo*, ‘Bart poured onto the ground juice’) received lower ratings than their canonical equivalents, they were by no means rated as unacceptable. Both received acceptability scores well above the midpoint of the scale, even though the sentences were presented in a neutral pragmatic context, rather than one in which a shifted locative would typically be used (e. g., when the first NP is surprising/emphasized, or the second NP is long/heavy). These data suggest that locative word order is indeed more flexible in Spanish than English. Consequently, while a child learning English could form semantic classes by clustering together verbs that appear in a particular position with respect to the figure and ground noun phrases (e. g., \_GROUND, FIGURE vs \_ FIGURE, GROUND), the relative order of these three constituents is not so reliable a cue to semantic class membership for learners of Spanish.

The second possible reason why semantic verb class formation appears to take longer for learners of Spanish than English is that the Spanish locative constructions may be more idiosyncratic than English, with verbs clustering less straightforwardly into classes with semantically-similar members (e. g., Hunter 2008). As we noted earlier, the evidence for this claim is not strong, relying as it does on assumption that it is possible to posit crosslinguistically-meaningful verb types. Nevertheless, if this turns out to be the case, it would explain the finding that Spanish learners displayed an interaction, such that evidence of the use of verb semantics increased with age, whilst English learners did not.

A possible objection to this ongoing discussion is that Spanish learners did not in fact show increasing use of verb semantics with age; that although adults showed more evidence of using semantic verb classes to guide their novel judgments than did the older children, so too did the youngest children. Recall from Table 4 that the 6–7 year olds showed such an effect for the novel *fill*-type verbs, while the 10–11 year olds did not show this effect for either the novel *fill*-type or *pour*-type verbs. There would seem to be three possible explanations for this pattern. The first is that we are seeing a genuine effect of “U-shaped” development here; that children form semantic verb classes, then discard them in some reorganization of the system, then re-form them as adults. This explanation not only seems intuitively implausible, but is at odds with the findings of all previous studies of the semantic verb class hypothesis (Gropen et al. 1989; Gropen et al. 1991a; Gropen et al. 1991b; Brooks and Tomasello, 1999; Ambridge et al. 2008; Ambridge et al. 2009; Ambridge et al. 2011), including both Ambridge et al. (2012) and Bidgood et al.’s (2014) studies of the English locative. The second and third possibilities are that (a) the apparent semantic verb class effect amongst the younger Spanish children or (b) the apparent lack of such an effect amongst the older Spanish children is an anomalous result. Although there is no clear way to decide between these two latter possibilities, the first is perhaps more likely, as it is consistent with the suggestion discussed above that semantic verb classes might be expected to develop more slowly in Spanish than English.

Despite differences in the developmental trajectory of semantic verb class effects, the finding that English and Spanish adults showed a similar pattern of judgments suggests that languages may display cross-linguistic similarities – if not hard and fast universals – with regard to the way that noun phrase arguments tend to be ordered in locative constructions. Such tendencies may be grounded in more general processing biases, such as a tendency to mention more “affected” noun phrases before less affected ones (e. g. Gropen et al. 1991a). On this account, at least part of the reason that both English and Spanish speakers *pour water into a cup* but *fill a cup with water* is that the former sentence conceptualizes the water as being more affected (by having its location changed) and the latter, the cup (by having its state changed from empty to full; see also Bidgood et al. 2014). Indeed, looking across all 12 languages studied, Hunter’s (2008) analysis classified 73 *pour*-type verbs as figure-only, 14 as alternating and just 4 (two Greek, one Polish, one Dutch) as ground-only. Conversely, of the *fill*-type verbs, 168 were classified as ground-only, 41 as alternating and just 17 (mostly from Japanese, Chinese, Korean and Hebrew) as figure-only (*fill water into the cup*).

Turning now to the statistical learning hypothesis, Spanish learners – like the English learners in the study of Bidgood et al. (2014) – displayed at least some evidence of verb frequency effects at all ages. One difference between the two studies, however, was that the magnitude of the frequency effect increased with



age only for the Spanish learners. Again, one possible explanation is that the more variable nature of Spanish locative word order hampers the statistical learning mechanism. For example, while an English child can straightforwardly learn that *fill* always appears before a Noun Phrase denoting some kind of container (e. g., *Lisa filled the box with paper*), this is not the case for a Spanish child, given the existence of sentences such as *¡Lisa llenó con piedras el vaso!*, ‘The girl filled with *stones* the glass!’, which places the figure and ground arguments in the same order as the ungrammatical figure-locative construction, which is ungrammatical for this verb (e. g., *\*Lisa llenó papel en la caja*).

The finding that Spanish children displayed an effect of statistical learning, but not of verb semantics (except the potentially-anomalous finding for the younger group) constitutes support for statistics-before-semantics accounts of the retreat from overgeneralization. For example, Tomasello (2003: 180) argues that “entrenchment works early... and semantic subclasses begin to work later”, while Perfors et al. (2010: 636) suggest that “although semantic information is ultimately used, syntactic information may be more important initially”. Indeed, such proposals would seem to make intuitive sense. In order for children to form semantic classes of verbs that appear in figure and ground locative constructions, they would first need to know which verbs appear in these constructions; information that – almost by definition – can only be learned distributionally. Note that the finding of no developmental differences in the study of Bidgood et al. (2014) does not necessarily count against a statistics-before-semantics account. Recall that, in this previous study, even the youngest children (aged 5–6) showed *both* statistical learning and semantic effects (perhaps because the locative alternation is less problematic in English than Spanish). Thus in order to test a statistics-before-semantics account in English, one would have to study children younger than 5–6 (presumably using a task that is easier for children than grammaticality judgments; e. g., elicited production or imitation).

Although some important differences were observed, when taken together, the findings of the English study of Bidgood et al. (2014) and the present Spanish study suggest that any complete account of the retreat from overgeneralization must be able to yield effects of both statistical learning and the (eventual) formation of semantic verb classes. One candidate account is the FIT model outlined by Ambridge et al. (2011), and applied to the domain of the (English) locative constructions in Ambridge et al. (2012). Although this account attempts to explain both semantic and statistical-learning effects, as a purely verbal model, it does not make precise quantitative predictions that can be verified experimentally.

An alternative account (Twomey et al. 2014) has been implemented as a computational model, and so does not suffer from this drawback. Interestingly, although the model yields semantic type effects, it does so using a purely distributional learning procedure. For example, the model might learn to display similar behaviour for *pour*, *drip*, *spill* and *dribble*, on the basis that all occur in similar distributional contexts (e. g., before the noun phrases “water”, “juice” etc.). Twomey et al.’s (2014) model is able to explain a variety of empirical findings relating to the acquisition of the English locative constructions, but has not yet been tested on other languages. It would be interesting to see whether the model is able to simulate the different patterns of locative acquisition shown by learners of Spanish and English on the basis of differences in the distributional patterns of the two languages. Indeed, the present findings suggest that crosslinguistic differences in the behaviour of verbs and constructions that are near synonyms constitute another important phenomenon that any successful account of language acquisition must be able to explain.

In conclusion, the findings of the present study suggest that, for learners of Spanish, both semantic and statistical-learning mechanisms are important in the retreat from overgeneralization, though the former perhaps only later in development. Taken together with findings from similar studies focusing on the acquisition of English, these findings highlight the need for crosslinguistic accounts of the acquisition of verb argument structure – and, indeed, language more generally, that incorporate both semantic and statistical learning.

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## Appendix A: Novel verbs and definitions

Novel verb	Definition (Spanish)	Definition (English translation)
novel <i>cubrir/ensuciar</i>	Es como cubrir, pero tiene que hacerse con barro	It is like covering, but it has to be done with mud
novel <i>llenar/forrar</i>	Es como llenar, pero tiene que ser con papeles	It is like filling, but it has to be done with paper
novel <i>regar/chispear</i>	Es como regar, pero tiene que ser un montón de líquido	It is like watering, but it has to be done with a lot of liquid
novel <i>salpicar/gotear</i>	Es como salpicar, pero tiene que ser con gotas gordas	It is like splashing, but it has to be in big blobs
novel <i>añadir/verter</i>	Es como añadir, pero tiene que ser en gotitas pequeñas	It is like adding, but it has to be in tiny drops
novel <i>tirar/esparcir</i>	Es como tirar, pero tiene que ser apretando un botón	It is like throwing, but it has to be by pushing a button

## Appendix B: Warm-up trials and literal English translations (illustrating the ungrammaticality of the Spanish sentence where appropriate)

<i>El gato bebió la leche</i>	The cat drank the milk
<i>*El perro la pelota jugó con</i>	*The dog the ball played with
<i>La rana atrapó a la mosca</i>	The frog caught the fly
<i>*Sus dientes hombre él cepilló</i>	*His teeth man the brushed
<i>*La mujer dijo el hombre una historia divertida</i>	*The woman said the man a funny story
<i>La niña telefoneó a su amiga las noticias</i>	The girl telephoned her friend the news
<i>El hombre susurró a su amigo el chiste</i>	The man whispered his friend the joke