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30-Month-Olds Use Verb Agreement Features in Online Sentence Processing

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1. Introduction

Languages signal the syntactic relationships among words in a sentence using two strategies: fixed word order and morphological marking. English relies primarily on word order, but retains vestiges of a morphological system that marks grammatical roles, including minimal subject-verb agreement. English-learning toddlers learn to use word order as a cue to syntactic role early (Hirsh-Pasek & Golinkoff, 1996; Gertner, Fisher & Eisengart, 2006), but what role does the morphological system play as children acquire English?

The current study asks whether toddlers use subject-verb agreement during online sentence comprehension in English, and if they do, how. English verbs agree with their subjects in person and in number, but in practice, most forms are identical (see Table 1). Given the minimal agreement system in English, one might expect agreement morphology to play little role in early language comprehension. If agreement does play a role in comprehension, however, there are two primary ways it might function: either through the semantics of agreement-marked verbs, providing a direct cue to number meaning, or through the syntax, by predicting or checking the grammatical number of the subject.

A better understanding of how toddlers use agreement gives us a new perspective on long-standing, central questions about the role of syntactic and semantic knowledge in language acquisition (e.g., Bowerman, 1973). How do learners formulate relationships between linguistic elements: in terms of meanings, formal properties or some of both?

For adult speakers of English, agreement is primarily syntactic: it is the grammatical number of the subject noun phrase, not the conceptual number of the thing it describes, that governs the verb's form (Corbett, 2006). Thus, (1) applies equally well to one pair of scissors on a desk as to a dozen in a preschool art class, and (2) can describe a single ear of corn or many.

Table 1. English verb agreement paradigms for BE and regular verb WRITE

BE	<i>singular</i>	<i>plural</i>	WRITE	<i>singular</i>	<i>plural</i>
<i>1st person</i>	am	are	<i>1st person</i>	write	write
<i>2nd person</i>	are	are	<i>2nd person</i>	write	write
<i>3rd person</i>	is	are	<i>3rd person</i>	writes	write

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- (1) The scissors look dull.
- (2) The corn looks s delicious.

Even agreement errors are governed by the grammatical properties of interfering nouns, rather than their conceptual properties. For example, in sentence completion tasks, adult speakers are more likely to produce an erroneous plural form following a complex subject with an embedded plural noun (e.g., *the drawer for the needles/tweezers...*), regardless of whether that plural noun refers to a single item or to more than one (Bock, Eberhard & Cutting, 2004).

How does agreement come to be primarily syntactic? Three threads in acquisition research suggest that agreement may be treated that way from the start. We briefly discuss each in turn.

First, although young children often produce bare or infinitival forms of verbs, the agreeing forms they do produce are almost invariably correct (e.g., Keeney & Wolfe, 1972; Wexler, 2011). Studies of spontaneous production permit few opportunities to observe plural agreement, because most subjects are singular (Rubino & Pine, 1998). However, even in elicited production tasks that provide such opportunities, young children demonstrate a good command of agreement. For example, Rissman, Legendre and Landau (2013) primed 32-month-olds to produce auxiliary verbs in a task requiring the children to produce a different agreeing form from the one they had just heard. Despite this challenge, children produced agreement errors on only 2% of trials.

Second, in contrast to this early mastery of agreement production, children fail to use agreement in explicit comprehension tasks until quite late. In one task, children see two pictures differing only in number (e.g., one vs. two ducks swimming in a pond) and are asked to point to the picture that matches a sentence. When the only cue to subject number is verb agreement (e.g., *the ducks swim_ in the pond*, where the initial /s/ of *swim* disguises the final /s/ of *ducks*, Johnson, de Villiers & Seymour, 2005; see also, e.g., Leonard, Miller & Owen, 2000; Miller, 2012), children appear oblivious to the conceptual number information it signals until the age of 5 or 6. A version of this task that measured eye-gaze as children listened to the sentences did find sensitivity to verb agreement in German-speaking 3- and 4-year-olds, but even that sensitivity was delicate (Brandt-Kobele & Höhle, 2010). When a second set of children were shown the same stimuli, but were asked to point to the matching picture, they showed no sensitivity to verb agreement in either eye-gaze or pointing.

Why might children fail to use verb agreement to infer conceptual number in comprehension, even though they successfully implement agreement in their own speech? Children are not oblivious to all linguistic cues to number: 2-year-olds look longer to a matching display when hearing a sentence with multiple linguistic cues to number (e.g., *There are some blickets!*, Kouider, Halberda, Wood & Carey, 2006), 2.5-year-olds accurately answer questions about quantity (e.g., *Are all the bananas in the red circle?*, Barner, Chow & Yang, 2009), and can use number marking on a novel noun to identify its referent (Jolly & Plunkett, 2008). Rather, it seems that using verb agreement as a cue to number mean-

ing is especially difficult. In picture-selection tasks, Nicolaci-da-Costa and Harris (1983, 1984) found that 3- and 4-year-olds were best able to use a number-marked determiner or noun (*this/these, girl/girls*) as a cue to number meaning, followed by forms of the auxiliary (*is jumping/are jumping*), and then by regular verb agreement (*jump/jumps*).

One possibility is that this pattern emerges because verb agreement does not independently carry number meaning, but serves a primarily syntactic role, reflecting the grammatical number of the subject (e.g., Johnson, de Villiers & Seymour, 2005). Number words, quantifiers and nouns, in contrast, carry number semantics and can be used to infer number meaning directly.

The sole exception to this pattern of early use in production and late use in explicit comprehension tasks is the success of 30-month-old French-learners in both preferential-looking and pointing tasks (Legendre, Barriere, Goyet & Nazzi, 2010; Legendre et al., 2013). Children more often chose a video of two boys kissing a novel object than of a single boy kissing a different object when hearing (3) as opposed to (4).

- (3) Ils embrassent le tak. /izɛ̃bʁaslətak/
‘They kiss the tak’
- (4) Il embrasse le gef. /ilɛ̃bʁasləgef/
‘He kisses the gef’

The authors argue that in modern spoken French, *ils*, though traditionally analyzed as a clitic pronoun, is better analyzed as a pre-verbal agreement marker. This is a cross-linguistically common diachronic change: pronouns become clitics, which become agreement morphology. If *ils* has completed this change, the young children in this study used agreement to infer number meaning. However, another group has used a similar technique to help determine the status of subject markers in Xhosa (Smouse, Gxilishe, deVilliers & deVilliers, 2012). They argue that if a marker is easily used to infer number meaning, it has not yet completed the transition from clitic to agreement. Thus another interpretation of the French results is that young children still interpret *ils* as a plural pronoun.

The third line of research hinting that agreement is syntactic from the start investigates infants’ distributional learning about the linguistic patterns involved in agreement. Before producing agreeing verbs, 1.5-year-olds are sensitive to some of the distributional dependencies created by agreement (e.g., Soderstrom, Wexler & Jusczyk, 2003; van Heughten & Shi, 2010). Toddlers listen longer to grammatical combinations of number-marked nouns and verbs than to ungrammatical ones (e.g., *The team_ bakes_ bread* > *The team_ bake_ bread*).

This sensitivity to agreement-relevant distributional patterns emerges even before children show clear evidence of having access to a conceptual distinction between ONE and MORE-THAN-ONE (e.g., Li, Ogura, Barner, Yang & Carey 2009). Infants and toddlers can represent small numbers veridically, tracking up to about 3 objects at a time. Thus, when toddlers see 3 objects hidden in a box, and are permitted to withdraw one, they continue to search for the remaining



objects. However, when toddlers younger than 22 months see 4 objects hidden in the box and withdraw one, they search no longer than if they had seen a single object hidden to begin with. This suggests that, faced with a quantity that exceeds their representational capacity, they cannot resort to MORE-THAN-ONE as a conceptual short-hand.

This pair of findings suggests that infants begin learning about number-relevant distributional patterns before they have appropriate conceptual distinctions to tie them to (see Soderstrom, 2008; Naigles, 2002 for similar arguments).

Once a conceptual distinction between ONE and MORE-THAN-ONE becomes available, in principle children might link it to morphological elements surrounding nouns (quantifiers, the plural affix), elements surrounding verbs (agreement), or both. Two considerations suggest that children might be led to link conceptual number distinctions to elements surrounding nouns, rather than to verb morphology. First, number appears more conceptually relevant to noun than to verb meaning. When a speaker says *my sisters are flying to Tucson*, there are multiple sisters, but likely only one flight. Verbs marked for plural agreement do not indicate a plural event in any straightforward way, whereas nouns with the plural affix do typically indicate a plural referent. Second, noun number marking in the input will tend to correlate better with number meaning than verb agreement will. After all, count nouns are marked as singular or plural wherever they appear in a sentence, but a verb only shows plural agreement when its *subject* is plural. The linguistic data should therefore support just the pattern of data that appears in the early comprehension literature: the best correlates of number meaning will be linguistic elements that are marked for plurality wherever they occur in the sentence, that is, the nouns, not the verbs.

If children treat agreement as primarily syntactic from the start, it seems natural that agreement markers would not convey number meaning robustly enough to support success in explicit comprehension tasks. But agreement might still be used in comprehension. In the current study, we created a context in which agreement could be used for its syntactic purpose: predicting the grammatical properties of the subject noun phrase. Toddlers heard simple inverted sentences (questions and locative inversions; Figure 1) in which a number-marked verb preceded its subject noun phrase. Each sentence accompanied a pair of pictures that differed in number and object-type (e.g., one apple, two cookies). All pictured objects had familiar count-noun names. In this constrained context, the agreeing verb predicts the upcoming noun: on hearing *where are...*,

Figure 1. Trial structure in the experimental condition

			
Informative:	Where are the good cookies?		<i>plural</i>
	Where is the good apple?		<i>singular</i>
Uninformative:	Can you find the good cookies?		<i>plural</i>
	Can you find the good apple?		<i>singular</i>

a listener can reject a single apple as a referent for the anticipated plural subject. If toddlers can use verb agreement this way in online comprehension, these *informative* sentences should facilitate noun comprehension, relative to *uninformative* sentences in which the target noun cannot be predicted in advance (e.g., *look at the...*).

We have previously used this task to demonstrate that 3-year-olds and adults use an agreeing verb to anticipate the properties of an upcoming noun (Lukyanenko & Fisher, 2010, 2013). Three-year-olds and adults were faster and more likely to shift their gaze from a distractor to the target in informative trials than in uninformative ones, and this advantage appeared even in a pre-noun measurement window. Thus, for older children and adults, the information carried by an agreeing verb facilitates the processing of the subject noun phrase, and also supports strong anticipatory processing.

The current study extended this task to younger children. Thirty-month-olds are still at an age where they are likely to omit auxiliaries and agreement markers in their own speech. Evidence that an agreeing verb nonetheless facilitates noun comprehension in our task would suggest that children's use of verb agreement in comprehension does not lag behind their productive abilities by years, as suggested by the explicit comprehension tasks reviewed above; instead, toddlers can use agreement for its syntactic purpose, in either production or comprehension.

It is worth noting that in versions of this task with 3-year-olds and adults, we find a consistent tendency for anticipatory effects of verb agreement to be carried by plural trials (Lukyanenko & Fisher, 2010, 2013). We anticipated that the same would be true for younger children, and also that younger children would be slower to use lexical-syntactic information as it became available (e.g., Fernald, Perfors & Marchman, 2006). Thus, we sought evidence of facilitation both before and after participants heard the target noun, and included plurality as a predictor.

2. Method

2.1 Participants

Sixty-four 2-year-olds participated (28.1-32.3 months, $M = 29.8$; 28 girls). All were learning English as their first language. Nine additional children were excluded because of reported language delay (5), refusal to participate (1), or inattentiveness or parental interference (3; see Coding below). Children's productive vocabularies, measured using the short form of the MacArthur Bates CDI (Level III; Fenson et al. 2007), ranged from 0 – 92 (median = 55.5).

2.2 Stimuli

Stimuli consisted of sentences each containing one of 8 familiar object-names, accompanied by photographs of the named object and a distractor, as shown in Figure 1. Sentences were recorded by a female native English speaker.

Informative trials used an inverted word order in which the verb preceded its subject, the target noun phrase (e.g., *Where are the good cookies?*). In uninformative trials, the target noun was not the subject of the sentence (e.g., *Can you find the good cookies?*). Because informative and uninformative trials involved different recorded sentences, we compared the experimental condition depicted in Figure 1 to a control condition in which participants heard the same recorded sentences, but saw target and distractor pictures that always matched in number. This rendered the early number-marked verb unhelpful, and thus in this referential context children should show no facilitation in 'informative' sentences with a number-marked verb relative to those without.

Pictures appeared in yoked pairs (dog-baby, cat-turtle, bike-truck, apple-cookie). Each pictured object served 4 times as target and 4 times as distractor, with target side counterbalanced. Participants received 16 trials of each type (informative, uninformative), each with 8 singular and 8 plural targets. Seven filler trials with a single picture were interspersed among the 32 critical trials.

2.3 Apparatus and Procedure

Children sat on a parent's lap, about 4 feet from a 50-inch TV screen. Parents wore opaque glasses that blocked their view of the screen. On each trial, two pictures appeared, aligned with the left and right edges of the screen. A camera beneath the screen recorded children's eye-movements.

In each trial, the pictures were visible for 7 seconds. The onset of the determiner in the critical sentence occurred 3 seconds after the pictures appeared; thus speech began approximately 2 seconds into the trial. Trials were separated by a 1-second blank-screen interval.

2.4 Coding

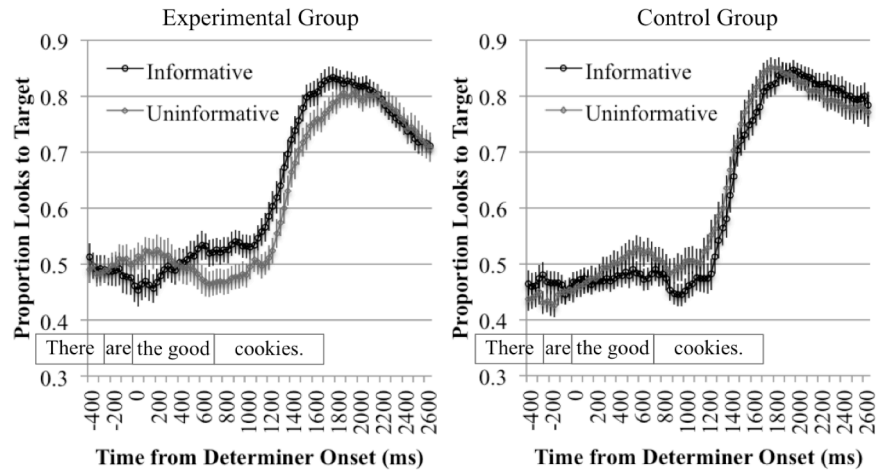
We coded where participants looked (left, right, away) during each 7-second trial, frame-by-frame from silent video. Reliability was calculated for 25% of the data. Coders agreed on 96% of all video frames. Individual trials were eliminated (174 of 2048 possible trials, 8.5%) if more than 50% of the trial was spent looking away or was uncodeable (123 trials), or if the child's or parent's speech obscured the critical sentence (51 trials; Fernald et al., 2008). Three children's data were excluded because such eliminations left fewer than 4 of the 8 possible trials of each trial-type/plurality combination (informative singular, informative plural, uninformative singular, uninformative plural).

3. Results

Figure 2 shows looks to the target as a proportion of looks to either picture in informative and uninformative trials, separately for the experimental and control conditions. Fixations to the target picture increased earlier in informative than in uninformative trials, in the experimental condition only. To evaluate this

pattern, we examined three measures: (1) the latency of the first shift from distractor to target measured from noun onset, (2) fixations directed to the target picture at noun onset, and (3) the likelihood of distractor-to-target shifts in an early window encompassing the determiner and adjective, but ending before the onset of the noun could have influenced children's looking.

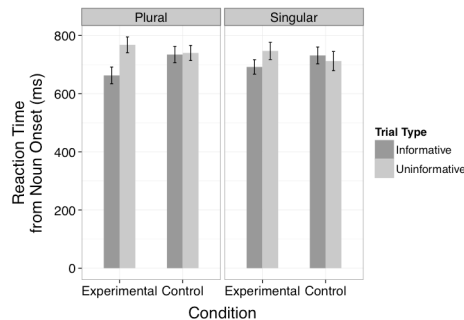
Figure 2. Mean (se) proportion looks to target.



3.1 Reaction Time

We measured the latency of the first shift in fixation from distracter to target, after the onset of the noun. If children use agreeing verbs to facilitate noun processing, they should need less information to identify the noun in informative trials in the experimental condition, leading to shorter latencies. We selected trials in which children happened to be looking at the distractor at noun onset, and in which they shifted their gaze to the target within a 1500 ms window extending from 300 ms after noun onset to 1800 ms after noun onset. Latencies shorter than 300 ms were excluded because they were deemed too early to be prompted by the noun (Fernald et al., 2008).

Figure 3. Mean reaction time from noun onset (se).



shorter than 300 ms were excluded because they were deemed too early to be prompted by the noun (Fernald et al., 2008).

As shown in Figure 3, children were quicker to shift to the target picture in informative than in uninformative trials; this was true only in the experimental condition. A multi-level model of reaction time was fit in R (R Core Team, 2013) using the *lmer()* function in the *lme4* li-

brary (Bates, Maechler & Bolker, 2013). Condition (experimental/control), trial type (informative/uninformative), plurality (singular/plural target), and all interactions were entered into the model as predictors. Predictors were coded using mean-centered effects coding. Random intercepts were included for subjects and target nouns; because a maximal random effects structure resulted in convergence problems, we used a forward best-path method ($\alpha = .2$) to determine which random slopes to include (see recommendations in Barr, Levy, Scheepers & Tily, 2013). Only the random slope for trial type by target noun met this inclusion criterion. The analysis revealed a significant interaction of trial type and condition ($\chi^2(1) = 9.28, p = .002$). All other χ^2 s < 1.5 .

Thus agreeing verbs facilitated 30-month-olds' online sentence comprehension: Children needed less information from the familiar noun itself if it was heralded by informative verb agreement. However, this measure investigates only effects occurring after the onset of the noun. Clearer evidence for anticipatory processing, as found with older children (Lukyanenko & Fisher, 2010), requires looking in earlier time windows. If participants used the information carried by the agreeing verb to *pre-activate* the number features of the upcoming subject, we should find effects of the agreeing verb at or before noun onset.

3.2 Noun-onset Looks

To determine whether children use agreeing verbs to anticipate properties of the subject before it began, we first asked whether children were already less likely to be fixating the distractor (as opposed to the target) at noun onset. This is the same point from which we measured reaction times above. At this point, children have received no information about the noun, but in informative trials have already heard a potentially useful agreeing verb.

Figure 4 shows children's likelihood of fixating the target at noun onset. By noun onset, children were more likely to be looking at the target in informative than in uninformative trials, in the experimental condition only. A binomial multi-level model of looks to distractor or target at noun onset was fit in R using the *glmer()* function of the *lme4* library. As before, predictors were condition, trial type and plurality, and a forward best path algorithm was used to determine the inclusion of random slopes. In this case no random slopes met the inclusion criterion ($\alpha = .2$). The analysis revealed a significant interaction of trial type and condition ($\chi^2(1) = 5.43, p = .0198$). Effects of plurality ($\chi^2(1) = 2.35, p = .125$) and the interaction of trial type by plurality ($\chi^2(1) = 2.10, p = .147$) were non-significant; all other χ^2 s < 1 .

The significant interaction of trial-type by condition indicates that, at noun onset, children were already more likely to be looking at the target than at the distractor, in the experimental relative to the control condition; see Figure 4. This is evidence for anticipatory processing in these young children. The presence of an informative agreeing verb directed children's attention to the target picture even before information from the noun was available.

Figure 4. Probability of looking to target at noun onset (se).

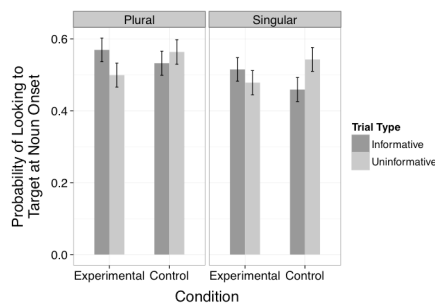
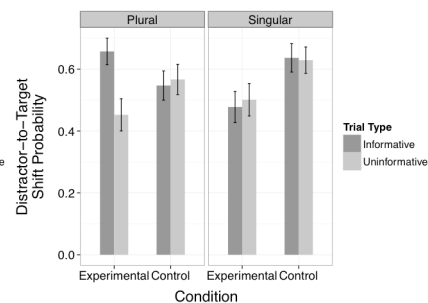


Figure 5. Probability of distractor-to-target shift in pre-noun window (se).



3.3 Distractor-to-Target Shifts

To get another view of the early effect of agreeing verbs, we assessed the likelihood of gaze shifts from the distractor to the target picture in a 900 ms pre-noun window. The window began 67 ms after determiner onset (and thus 300 ms after the average onset of *is* or *are* in informative trials), and ended 300 ms after the earliest noun onset. Figure 5 shows the proportion of distractor-initial trials that included a shift from distractor to target in this early window. Such shifts were most likely in the plural informative trials in the experimental condition, suggesting that an informative agreeing verb encouraged shifts to the target in those trials.

Shifts were analyzed using a binomial multi-level model, with predictors and coding as described above. No random slopes met the inclusion criterion. This analysis revealed a significant interaction between condition and plurality ($\chi^2(1) = 5.23, p = .022$), a marginal interaction of condition and trial type ($\chi^2(1) = 3.09, p = .079$), and a marginal 3-way interaction of condition, trial type and plurality ($\chi^2(1) = 3.22, p = .073$). There were no significant effects of condition ($\chi^2(1) = 2.06, p = .151$) or trial type ($\chi^2(1) = 2.40, p = .122$), and the interaction of trial type and plurality was not significant ($\chi^2(1) = 2.63, p = .104$).

These analyses suggest that any effect of informative verb agreement on anticipatory shifts was carried by plural trials. Upon hearing the verb-form *are*, 30-month-olds tended to look away from a picture showing a single item. This echoes the patterns we have found with older children and adults (Lukyanenko & Fisher, 2010, 2013): The anticipatory effects of agreeing verbs tend to be stronger in plural than in singular trials.

4. Discussion

When an agreeing verb provided advance information about properties of the noun, 30-month-olds were faster to look to the named picture. Furthermore, this effect began to emerge in an early window in which looking could not be influenced by the noun itself: in plural trials, toddlers were already marginally

more likely to shift gaze from the distractor to the target picture in the pre-noun window, and by noun onset children were already significantly more likely to be fixating the target. These data demonstrate early use of agreement in comprehension, and provide new evidence of anticipatory processing in early language comprehension. The present data add to previous findings showing anticipation of an upcoming noun based on constraining verb semantics (e.g., *you can drink the juice*; Fernald et al., 2008), and facilitation of processing at the noun based on morphosyntactic cues that were informative in the referential context (e.g., *la_{FEM} pelota_{FEM}* “the ball”, shown: ball_{FEM}, shoe_{MASC}; Lew-Williams & Fernald, 2007; *les_{PL} chiens* “the dogs” shown: one cat, two dogs; Robertson, Shi & Melançon, 2012). The current study represents the earliest evidence that young children can use a morphosyntactic cue to *pre-activate* linguistic features.

We have found a singular-plural asymmetry across a number of studies: plural trials tend to show stronger effects than singular trials. In the current study, this was reflected most clearly in the stronger effect of trial type on distractor-to-target shifts in the pre-noun window in the plural trials. There are several potential explanations for this pattern. First, it may be that the singular is less informative because it is the syntactic default and is therefore the unmarked value (e.g., Bock, 1995; Wagers, Lau, & Phillips, 2009). Second, it may be that the plural is simply more informative in the experimental context. When looking at a picture of two objects and hearing *Where is*, it is possible that the speaker is about to refer to one of the two; the parallel ambiguity is less obvious in plural trials (viewing one object and hearing *Where are*). Third, agreement is sometimes neutralized in casual speech in many dialects of English, especially in inverted contexts such as those in our experiments (e.g., Hay & Schreier, 2004). Children may often hear sentences such as *There's cookies*, rendering *is* less predictive of a singular subject than *are* is of a plural one.

Thirty-month-olds' use of agreement in online comprehension provides a marked contrast to older children's inability to use agreement to infer number meaning in explicit comprehension tasks. This difference is consistent with our proposal that children treat agreement as a syntactic relationship and use it that way in comprehension. However, additional questions need to be addressed before we can strongly conclude that toddlers used agreement as a primarily syntactic relationship in our task. We predicted children's success precisely because our task allowed agreement to play its ordinary syntactic role. But in principle, children might have succeeded either by using the form of the verb to infer conceptual number directly, that is, by interpreting *are* to mean MORE-THAN-ONE, or by using the form of the verb to predict grammatical properties of the upcoming noun. After all, most nouns are count nouns, for which conceptual and grammatical plurality coincide; thus *are* may predict a conceptually plural subject with sufficient reliability for children to use this regularity in online comprehension.

Additional data suggest that children treat agreement primarily as a syntactic relationship. Slightly older children succeeded in a variant of the present task in which conceptual number was held constant within each trial (Lukyanenko & Fisher, 2012). We showed 38-month-olds pairs of pictured objects named by

familiar nouns of three types: count (e.g., *shirt, banana*), invariant plural (e.g., *pants*) or mass (e.g., *toast*). By combining such items we created picture pairs that differed in grammatical number but not conceptual number. Three-year-olds were faster to look to the target object in trials in which grammatical number differed (one shirt, one pair of pants) than in trials in which grammatical number matched (two shirts, two pairs of pants). Thus, slightly older children can use grammatical number alone to succeed in a similar task, and effects were of similar size and timing to those in the 3-year-old version of the present study.

To get a better sense of how children represent this relationship and what information the agreeing verb conveys to them, there remain many questions to address. A study that is currently underway pits conceptual and grammatical number against each other, again by making use of non-count nouns. On some trials the conceptual number of the target is congruent with its grammatical number (e.g., two pairs of glasses), while on other trials it is incongruent (e.g., one pair of glasses). Is conceptual number truly irrelevant to agreement, or will incongruent conceptual and grammatical number impair processing as compared to congruent number features? Because all target nouns are non-count nouns, the number of pictured objects is irrelevant to verb marking. All the same, preliminary results with adult participants suggest that for adults both conceptual and grammatical number play a role. The version with children is ongoing.

Further research will be required to determine precisely how children represent the agreement relationship, but the current study provides clear evidence that 30-month-olds use agreement in comprehension, and in combination with previous studies, suggests that agreement is primarily syntactic from the very beginning.

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