Exhaustive Pairing Errors in Passives

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1. Background

Children often make errors with universal quantifiers, rejecting sentences like (1) for Figure 1, in contrast to adults, who generally accept these sentences. When children reject these sentences, they will point to the extra, unpaired object, claiming 'No, not that one'. This exhaustive pairing (EP) error, also known as 'quantifier spreading' (Roeper & de Villiers, 1991) and 'symmetrical response' (Philip, 1995), has been studied for decades now (Inhelder & Piaget, 1958).

(1) All the girls are eating apples.

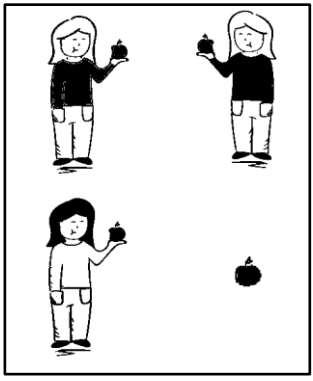

Figure 1. Girls and apples in an extra-patient situation[1]

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[1] These are typically referred to as 'extra-object' situations in the literature. Given that in passives the patient argument (which is the direct object in actives) appears in subject position, we will refer to these situations with an extra entity that is not acted upon by an agent participant as 'extra-patient' situations.

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The developmental path of EP-errors follows a U-shaped curve. Between the age of 4 and 7, children's performance on extra-patient items such as Figure 1 drops from 82% accuracy at age 4 to 28% at age 7 (Aravind et al., 2017). Accuracy subsequently improves slowly until the age of 9 and even at age 12 occasional children still show EP errors (Roeper, Pearson & Grace, 2011). Note that in the studies that also report individual findings, individual children are quite consistent in their answers, either making mostly EP errors or mostly responding adult-like (de Koster, Spenader & Hendriks, 2018).

One set of accounts has attributed the source of EP errors to performance issues, notably, methodological flaws (Crain et al., 1996; Kiss & Zétényi, 2017; Aravind et al., 2017), or limited cognitive resources (Freeman et al., 1982; Brooks and Sekerina, 2006). Another set of accounts posits partial linguistic competence either with respect to universal quantification (Drozd, 2001; Geurts, 2003; Kang, 2001; Philip, 1995, 2011; Roeper, Strauss & Pearson, 2006), or, more recently, with respect to the indefinite NP (Denić & Chemla, 2020). Before turning to the goal of the current study, we briefly present some of the explanations of EP errors, while summarizing the main findings thus far.

As for accounts that assume full linguistic competence, several explanations point out issues with the visual stimuli. Kiss and Zétényi (2017) claim that the 'economy of the stimulus' (p. 17), pointing out the rather artificial nature of the pictures, leads the child to incorrectly believe that all irrelevant elements have been omitted from the picture, and so each of the visual elements that are present must be somehow relevant. They found a reduction in EP errors when using more ecological, life-like pictures instead of the classic, 'economic' stimuli. In a similar vein, Aravind et al. (2017) argue that children think that the universally quantified sentence is underinformative given the visually salient, extra object, but, in contrast to adults, lack the pragmatic skills to conclude that only part of the visually salient sets is relevant to what the experimenter was asking. Brooks and Sekerina (2006) instead claim that the source of EP errors lies in children's limited cognitive resources. For distributive contexts, selecting the right set of entities under quantification is more difficult because of the symmetry in the one-to-one pairings of agents and patients (in contrast to a many-to-one pairing in collective situations). This difficulty then leads children to resort to 'shallow processing', which relies on an underspecified and easier to process syntax-semantics representation, where pragmatic and visual cues fill in the gaps.

The other type of account argues that there is a stage of incomplete syntax and/or semantics in the development from child to adult grammar. On the syntactic account of Roeper et al. (2006; see also Philip, 1995; Roeper & de Villiers, 1991), universal quantifiers are initially analysed as sentential adverbs instead of nominal quantifiers, and as such quantify over the whole event. In the pre-adult stage, the quantified NP is in a Focus Phrase, which requires that agents and patients are related in a distributive one-to-one fashion. Only when children get to the adult stage, do they analyse the quantified NP in situ, and no longer require a distributivity feature for the other NP.

The account by Drozd (2001) focuses instead on an immature semantic representation of universal quantifiers in children. In his view, children initially view universal quantifiers as weak ones. Consider the following three sentences ((2) is from Drozd, and (3-4) from Westerståhl, 1985):

(2) Every Scandinavian has won the Nobel prize in literature
(3) Many Scandinavians have won the Nobel prize in literature
(4) Many winners of the Nobel prize in literature are Scandinavians

In (2) with the strong quantifier *every*, it needs to be checked whether or not all the members of the NP under quantification (the *Scandinavians*) are also in the set of Nobel prize winners to determine whether the sentence is true. Extra, non-Scandinavian winners do not influence the truth value in any way. However, this does not hold for a weak quantifier like *many*: adults typically interpret (3) as (4). The truth of *many* in (3) is dependent on the relative number of Scandinavian Nobel prize winners (i.e. it is true if there is a disproportionately high number of Scandinavian winners). This dependency of a weak quantifier on the object NP set causes EP errors in children, according to Drozd.[2] The development from child to adult grammar, then, involves learning that universal quantification does not depend on expectations about the other mentioned set.

Another, recent account that posits immature semantics-pragmatics focuses on inferences derived from the indefinite noun phrase in object position, instead of issues with the quantifier. Thus, Denić and Chemla (2020) argue that in the children's interpretation, the indefinite NP elicits similar domain alternatives under the scope of a universal quantifier (5), as adults infer with modal verbs (6).

(5) Every girl took an apple.
-> Every (relevant) apple was taken by some girl.

(6) John can read an article.
-> John can read Article 1, he can read Article 2 and he can read Article 3.

Although children show very low rates of drawing inferences with, for example, scalar implicatures, they usually are able to derive inferences based on domain alternatives (Pagliarini et al., 2018). Here, the child must learn that indefinites under the scope of universal quantifiers do not act similarly as modals, or, in case adults make these inferences too but have other mechanisms to block them in the case of universal quantification, children must acquire the piece of the adult grammar responsible for that.

For the type of approach that explains EP errors in terms of performance issues (methodological problems or cognitive limitations), the syntactic properties of the test sentences should not play a role. Nevertheless, while practically all

[2] Thus, children can interpret the sentence 'all the girls are eating apples' as asking about the speaker's expectations, or even more general expectations about apple-eating girls.

previous studies investigated subject quantification, the few studies that tested quantifiers in different syntactic constructions, found that syntax mattered. In particular, there seems to be an interesting asymmetry in children's performance on universal quantification between transitive versus intransitive verbs, and between subjects versus objects. Philip (1995) found that there were fewer exhaustive pairing errors when the quantified noun phrase was used in intransitive sentences than in transitive sentences. And Kang (2001) found a higher rate of EP errors with object quantification than with subject quantification, in both English and Korean. This effect was also found for English learners in Brooks and Sekerina (2006) with actional verbs such as 'washing'.

Moreover, discourse has been found to play a role in several other studies, in particular, topicality of the quantified noun phrase greatly reduced the number of EP errors. Drozd and van Loosbroek (2006) found that Dutch children performed drastically better when the quantified set was introduced in a story before the test sentence. Yet when comparing subject and object quantification, Hollebrandse (2004) found that EP errors still appeared with quantified objects, despite the discourse context, even though these errors virtually disappeared with quantified subjects when the set denoting the subject noun was introduced in previous discourse. By manipulating both syntax (subject- and object quantification) and topicality, Hollebrandse thus found that the facilitating effect of topicality was modulated by grammatical function in the child grammar. Accuracy was much higher for topic subjects than for non-topic subjects, while at the same time topicality did not play a role for objects, as the EP error rate remained high.

2. Present Study

Most acquisition studies on universal quantifiers have used active transitive sentences with the quantifier in subject position, invariably finding EP errors when sentences were presented without a discourse context (for a review, see Drozd et al., 2019; Philip, 2011). The few studies that used other types of syntactic constructions found sensitivity to the type of structure, suggesting that the exhaustive pairing interpretation pattern is to some extent determined (either triggered or reduced) by syntactic properties. Different rates of EP errors have been found for quantification in transitive versus intransitive sentences (Philip, 1995) and subject versus object quantification (Hollebrandse, 2004; Kang, 2001).

The finding that EP errors do not appear consistently across different syntactic constructions suggests that, in the children's grammar, the semantics of quantification is somehow sensitive to the syntax. In particular, the interaction of topicality and grammatical function for triggering or avoiding EP errors (Hollebrandse, 2004) suggests that there is a connection to the notion of markedness. Quantifiers in unmarked constructions (subjects are typically topics, Lambrecht, 1994) were interpreted target-like, in contrast to quantifiers in marked constructions (sentences with a subject that was not the topic and sentences in which the direct object was a topic). This raises the question if there are any other

cases in which syntactic-semantic markedness affects children's interpretation of quantified noun phrases.

Another case of syntactic-semantic markedness is the passive voice. In most linguistic views, the passive is derived from the active. This means that an active sentence has an unmarked, canonical order with the agent before the patient, while the passive variant has a marked, patient before agent order. The subject of the active sentence (7) carries an agent-role, whereas the subject of its passive variant (8) (the former object) carries a patient-role. The theta-role properties of the subject of passives are thus marked as compared to active sentences.

(7) Mary was pushing a pram.
(8) The pram was being pushed by Mary.

In addition, the (agent) subject in active sentences is a canonical topic (Lambrecht, 1994), whereas the (patient) subject of a passive is not. This is not to say that subjects in passives can never be topics (Kuroda, 1979), but they are less likely to be topics (Balazs Suranyi, p.c.). If quantifiers are interpreted more easily in unmarked constructions (as Hollebrandse's (2004) findings suggest), they will be harder to acquire in passives than in actives. It is expected that there will be a difference in subject-quantification between active and passive sentences; children are likely to make more of EP errors for passives than for actives.

3. Method

3.1. Participants

75 English monolingual children (mean age = 7;1, range 5;8–10;7) were recruited from an English primary school.[3] They were tested individually in a quiet room in the school. Ten English adults were tested (mean age: 24.7, range 19–46) as a control group; they all performed at ceiling. The parents of the children and the adult participants signed for informed consent.

3.2. Procedure

The experiment consisted of a pretest and a main test. During the pretest, participants were shown pictures and were told that they were going to help a puppet animal learn to speak English. The puppet would describe the picture to them, and if the puppet said something wrong, the participant needed to say so and tell the puppet why it was wrong. In the training phase, the puppet made many obvious mistakes by mentioning wrong colours, wrong agents or naming a different event, and the child was encouraged to correct the puppet. During the pretest, only active sentences were used, and participants were identified as

[3] 16 more children participated in the pretest, but not the main test, and thus are not considered here. They either failed the control items (N=8), did not want to participate anymore (N=7) or made up elaborate stories as their answers (N=1).

exhaustive pairers (EP-group) or adult-like based on their performance, similar to Hollebrandse (2004). Between the pretest and main test, there was a short break to prevent fatigue. Then the child was asked if they wanted to play the game again. If they wanted to continue, they were shown more pictures and listened again to the puppet; this time there were more items, including passive sentences. On average the pretest took about 5 minutes and the test about 15 minutes.

3.3. Design

The pretest served to identify which children qualified as exhaustive pairers. There was one test condition with a quantified subject in active sentences presented for extra-patient situations. Children were assigned to the EP group if they rejected these sentences (4 or 5 times out of 5 test items), and to the adult-like group if they accepted these sentences (4 or 5 times out of 5). The children with 2 or 3 correct answers were still tested on the main test, but their data is not considered here. In addition, there were two types of control conditions targeting yes and no-answers, respectively.

The main test had a 2x2x2 design, manipulating two within-subject variables: Voice (active/passive) and Situation (extra-agent/extra-patient), creating four conditions, and one between-subject variable, namely participant Group (EP / adult-like). The Group variable was based on the children's performance on the pretest. The active condition in the main test served to ascertain this grouping.

3.4. Stimuli

The extra-agent items (Figure 2, left panel) showed a situation with three agents, each doing a given action on an object, plus one additional agent without an object. For this situation, the target answer for the quantified sentence in the active voice, (9), was rejection, because the set of agents was not exhausted ("no, one boy is not eating a banana"). In contrast, the target answer for the passive voice, (10), was acceptance, because all patients were indeed involved in the action. The extra-patient items (Figure 2, right panel) involved a situation with three agents each doing a given action on an object (the patient of the event), plus one additional object. Here, the target answer for the active voice, (11), was acceptance because the set of agents was exhausted. But now the target answer for the passive voice, (12), was rejection, because not all objects were involved in the action ("no, one apple is not being eaten").

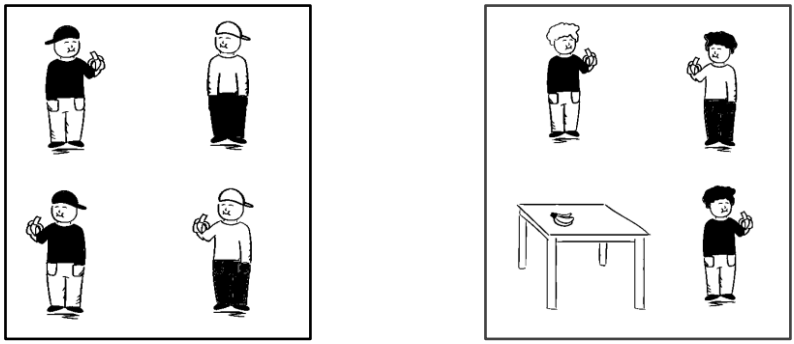

Figure 2. Extra agent item (left), and Extra patient item (right)

(9) All the boys are eating bananas
-> FALSE with the left picture & TRUE with the right picture

(10) All the bananas are being eaten by boys
-> TRUE with the left picture & FALSE with the right picture

In the pretest there were four training items, six experimental items and six control items, all in the active voice. The experimental items were all extra-patient situations. Of the control items three were clear yes-targets, showing a one-to-one distribution of agents and patients, and three others were clear no-targets, showing an extra agent. One pretest experimental item was later removed from the analysis[4], leaving five extra-patient items. The main test included 20 experimental items with five items in each of the four within-subject conditions, plus six control items with a one-to-one distribution of agents and patients (yes-targets).

4. Results

In the pretest, 43 of the 75 children answered non-adultlike, rejecting 4 or 5 out of the 5 active voice extra-patient items, and were labelled as the 'EP-group'. 14 other children answered correctly, accepting 4 or 5 out of the 5 critical items, and were labelled 'adult-like'. The remaining 18 children either had inconsistent answers (N=15), incorrectly accepted extra-agent items (N=2) or incorrectly rejected one-to-one items (N=1). Their data is not included in the analyses below.

The average accuracy per condition for the EP- and adult-like groups is visualized in Figure 3. The EP-group was very consistent in their answers (either all mostly correct or all mostly incorrect). In contrast, there was much variation in the responses on the passive condition from the adult-like group. In fact, only three children performed fully adult-like on actives as well as passives. Surprisingly, the remaining eleven, despite doing well on actives, did not perform

[4] The accuracy rates for this item were extreme outliers, possible because the extra patient may have been poorly visible, since it was relatively small and light-coloured.

equally well on passives: they made EP errors and/or erroneously accepted extra-patient situations.

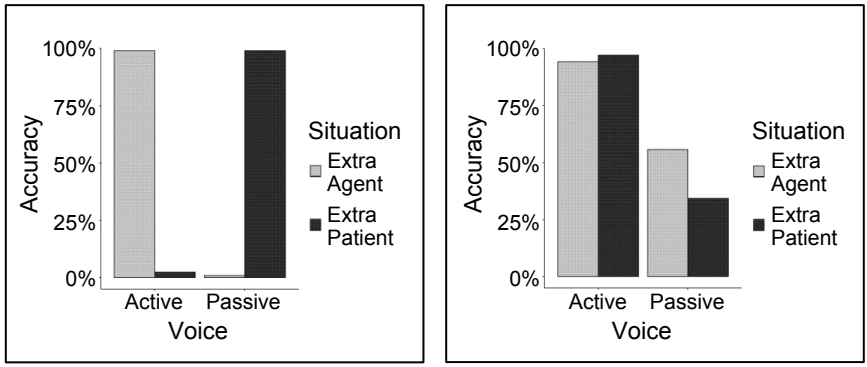

Figure 3. Average accuracy of the EP group (left, N=43) and the adult-like group (right, N=14) by Voice and Situation

We ran a logistic mixed-effects model in R (R core team, 2020) using the *lme4* package (Bates et al., 2015). Model selection was performed in a backwards stepwise selection, starting from the maximal model, which included random intercepts by subject and items and random slopes for all fixed factors by subject and by items. The random structure of the final model included intercepts for subjects and items, plus random slopes for all fixed effects without an interaction by subjects, but no random slopes by items. As fixed effects, we entered Voice (active/passive), Situation (extra-agent/extra-patient) and Group (EP/adult-like) with interaction terms into the model. Helmert coding was used for the contrasts for all fixed effects. P-values for the effects were obtained by likelihood ratio tests of the full model with the effect against a model without that effect. The output of the model and its R formula are presented in Table 1.

Table 1. Logistic mixed-effects regression model on accuracy data (fixed effects and interactions below α=.05)

	Estimate	Std. Error	*z* value	*p*-value	
Voice	-3.282	1.164	-2.819	.004	**
Group	4.265	1.878	3.487	< .001	***
Voice * Situation	9.499	1.878	5.057	< .001	***
Voice * Group	-5.827	2.324	-2.507	.012	*
Voice * Situation * Group	-37.81	4.868	-7.768	< .001	***

*R code: glmer (Accuracy ~ 1 + Voice * Situation * Group + (1 + Voice + Situation + Group | Subject) + (1 | Item), data=data, family=binomial)*

There was a main effect of Voice (β = -3.282, SE = 1.164, p = .004), meaning that on average, children performed better on active voice items (mean accuracy of 62%) than on passive voice items (48.8%). There was also a main effect of Group (β = 4.265, SE = 1.878, p < .001), meaning that children in the adult-like group were on average better (70.4%) than the EP group (50.3%).

The interaction between Voice and Situation (β = 9.499, SE = 1.878, p < .001) means that the accuracy on active sentences was higher for extra-agent situations (97.9%) than for extra-patient situations (25.6%), yet for passive sentences, the accuracy for extra-agent situations (14.4%) was lower than for extra-patient situations (83.2%). There was also an interaction between Voice and Group (β = -5.827 SE = 2.324, p = .012), meaning that performance on actives (95.7%) differed significantly from passives (45%) for the adult-like group, but not for the EP group (accuracy on actives 51.9% and passives 48.8%).

Finally, there was a three-way interaction of Voice, Situation and Group (β = -37.81 SE = 4.868, p < .001), revealing that, for each of the two situations, the accuracy was similar per voice in the adult- like group, but vastly different in the EP group. Performance per voice was more or less similar in the adult-like group (in the active voice 94.3% vs 97.1% and in the passive voice 55.7% vs 34.3%). In contrast, the EP-group performed very differently on the two situations for each voice (in the active voice 99.1% vs 2.3%, and in the passive voice (0.9% vs 99.1%). The three-way interaction consolidates the interaction between Voice and Situation in the EP-group, and simultaneously shows that it did not play a role in the adult-like group.

5. Discussion

The goal of the current study was to investigate the acquisition of universal quantification in non-canonical structures to see if such structures would influence the rate at which children make EP errors. Specifically, we investigated passive sentences that describe extra-agent situations, to see if these errors occur at similar rates as with active sentences that describe extra-patient situations. The results from the EP-group showed that children who make EP errors on active sentences (for extra-patient situations), indeed also make EP errors on passive sentences (for extra-agent situations), and do so at similar rates. However, there was a group of children who performed adult-like with active sentences, but performed worse on passives, where they suddenly started making errors. So, the markedness of the syntactic construction indeed mattered, at least for the adult-like group: universal quantification seemed to be interpreted target-like for unmarked structures with an agent subject in active sentences, but interpretation was not target-like for marked structures with a patient subject in passive sentences.

Replicating the exhaustive pairing interpretation found in many earlier studies with active sentences, the present study has revealed that this error was systematic as it extended to passive sentences: in the EP group, the EP error rate was near 100% in both voices. The finding of EP errors in passives is novel in the

literature on the acquisition of universal quantification.[5] It is compatible with both types of EP-accounts: those that seek to explain EP errors in terms of performance issues, as well as those that claim EP errors stem from incomplete knowledge.

The finding that there were children who performed well on actives (no EP errors), but bad on passives is also new, and raises the intriguing question as to why these children would make errors in one condition and not in the other. It speaks to the debate about the nature of EP errors, because variable behaviour (correct interpretation in one voice but errors in the other voice) cannot be explained by theories that explain EP errors in terms of performance errors or cognitive limitations. The methodological problems pointed out by earlier accounts as causing confusion in children here applied equally in both voices (artificial nature of the pictures, Kiss & Zétényi, 2017; confusing visual salience of an extra object, Aravind et al, 2017). Similarly, an account that relies on cognitive limitations (Brooks & Sekerina, 2006) would not expect a difference between actives and passives, at least not likely in the current study[6]. Nevertheless, the finding that there was a sizable enough subgroup of children (11/14 of the adult-like group), who made errors only in passives, not in actives, does not support the cognitive limitations account.

If methodological issues or cognitive limitations cannot explain the behaviour of the adult-like group, then the cause of EP errors must lie instead in the learner's grammatical system. Given previous findings in the literature on topicality and syntactic influences (Brooks & Sekerina, 2006; Drozd & van Loosbroek, 2006; Hollebrandse, 2004; Kang, 2001), the issue seems to lie in the learner's incomplete acquisition of the syntax-semantics mapping. Specifically, in the early stages quantified noun phrases are mapped correctly only if they are topic, agent and subject. Quantification of non-topics, patients and/or objects involves marked constructions and these have elicited (more) EP errors. Our findings support this for the marked patient subject in passives.

This raises the following question: which properties of active sentences help children interpret universal quantifiers in an adult-like way, and what is it about passive sentences that hinders them? Given that there is an interaction of syntactic, semantic and pragmatic properties in which actives differ from passives, it is difficult to pinpoint exactly which of them has had an effect on children's interpretations. The challenge is thus to disentangle the possible causes of the effect: do the adult-like children have more difficulty with quantification in passives because the quantified patient is in a non-canonical syntactic position? Is quantification of patients inherently more difficult than that of agents, possibly because agents are more salient in the visual input (because they are animate and in control of the action)?

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[5] Philip (1995) piloted a study on EP errors with passives, but he had a relatively young participant group and used only two items with passives in this pilot.

[6] We did not have passive comprehension controls, but most of our children were older than the age of five, when passives are acquired in English (Armon Lotem et al., 2016). Moreover, the passives in our study were "easy" because they involved irreversible verbs and had prototypical agents and patients.

The present study cannot answer these questions. Nevertheless, we can make some concrete predictions for follow-up studies to probe further into these matters. If the problem lies in the marked syntactic form of passives, it is expected that EP errors also arise in other marked sentence forms, in particular, when agent and patient do not appear in their canonical position, as in clefts (e.g. *It is apples that all the girls are eating*). If the problem is caused by the marked nature of having a patient in subject position, then EP errors are expected to be found with other atypical subjects (e.g. experiencer or stimulus subjects with psychological verbs: *Every spider was scaring a child*) and reversible passives (e.g. *All the girls are kicking boys* vs. *All the boys are being kicked by girls*). And if the issue lies with patient quantification, EP errors should also appear with short passives (e.g. *All the apples are being eaten).* Short passives also provide a good testing ground for verifying Denić and Chemla's (2020) account, which locates the source of EP problems in the indefinite object noun phrase in active sentences; short passives lack an indefinite NP (in a by-phrase) that could trigger the supposed domain-alternatives.

6. Conclusion

We have found that children who make EP errors with actives also make EP errors with passives. In addition, there was a group of children who seemed adult-like on the active voice items, but performed worse with passives. We argue that children's syntax-to-semantics mapping is immature: the learner has not acquired a mapping system for properly quantifying over non-topics, non-subjects and/or non-agents. Further research could look at the acquisition of quantification with short passives or other non-canonical syntactic constructions, as well as the topicality of the quantified patient subject.

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