Q-spreading in child language as distributive inferences*

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1 Missing implicatures in adult language

1.1 Disjunctions: free choice and distributive inferences

Disjunctions in the scope of a possibility modal trigger so-called *free choice inferences*: (1a) implies (1b) (e.g., Kamp, 1973).

(1) a. John can read Article 1, Article 2, or Article 3.
b. John can read Article 1 and John can read Article 2 and John can read Article 3.

Such inferences are typically (but not always) derived as implicatures, crucially relying on the fact that 'P(A1 or A2 or A3)' triggers 'domain alternatives' of the form: P(A1 or A2), P(A1 or A3), and P(A2 or A3). All details and motivation can be found in Fox (2007).

Notwithstanding the technical details, assume that we can thus consider free choice inferences as evidence for the fact that the disjunction activates these alternatives. Given most theories of implicatures, say Chierchia et al. (2008) for concreteness, this makes an immediate prediction for how the disjunction is interpreted in the scope of the universal quantifier, as in a sentence such as (2). For our purposes, implicatures are obtained as negations of alternatives. With P(__) now being *Every girl took* __, we obtain the inferences that 'not every girl took Apple 2 or Apple 3 or Apple 4', hence 'some girl took Apple 1', and similarly for all apples: 'some girl took Apple x'.

(2) a. Every girl took Apple 1, Apple 2, Apple 3, or Apple 4.
b. Every apple was taken.

In sum, given the alternatives evidenced by free choice inferences ((1)), one may derive implicatures and judge (2a) as not true in the situation depicted in Figure 1. This prediction is borne out, these implicatures are called distributive inferences (see, e.g., Spector, 2006 and quantitative data in Crnič et al., 2015 and Appendix B).

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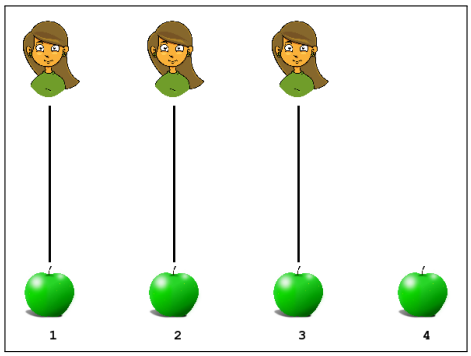

Figure 1: Every girl took an apple, but not every apple was taken.

1.2 Indefinites: free choice but no distributive inferences

Indefinite noun phrases also trigger free choice effects in the scope of a possibility modal: in a context with three salient articles, a possible reading of (3a) is (3b).[1]

(3) a. John can read an article.
b. John can read A1 and he can read A2, ...

Arguably, this free choice reading may be similar to the one above, and therefore it may be taken as evidence that indefinites activate domain alternatives. Just as it was the case for disjunctions, this makes a prediction for cases such as (4a), in which the indefinite appears in the scope of the universal quantifier, namely that it could be read as (4b), and therefore be judged not true in the situation depicted in Figure 1. But there is no experimental or introspective evidence for such a reading in adults (cf. Appendix A).

(4) a. Every girl took an apple.
b. Every girl took an apple and every apple was taken by some girl.

To sum up, if free choice effects are a signal of exhaustification of domain alternatives, observed for both disjunction and indefinite, then distributive inferences are predicted for both disjunctions and indefinites in the scope of a universal quantifier. However, distributive inferences are only attested for disjunctions.

2 Children: q-spreading as distributive inferences

Strikingly, children seem to have the exact interpretation of the indefinite in the scope of the universal quantifier that is predicted, yet unattested, in adult language. That is, they would report that (4a) is false in a situation as in Figure 1. This phenomenon in child language has been called quantifier spreading (hereafter q-spreading), Type A error, or exhaustive pairing error. It has been extensively studied at least since Inhelder and Piaget (1964).

[1] The indefinite in (3) can also get a specific interpretation; (3) thus has a reading in which there is a particular article which John can read, but this is not the reading that concerns us here.

2.1 Q-spreading as distributive inferences

Given the previous discussion, an account of q-spreading is readily available: whatever is responsible for the different behaviors of indefinites and disjunctions in the scope of a universal quantifier in adult language is not operative in child language. Q-spreading in child language may thus be the result of implicatures, derived by negating domain alternatives that indefinite noun phrases ought to activate, since they give rise to free choice inferences.

Such an account is coherent with and similar in spirit to the account of Singh et al. (in press) for the conjunctive interpretation of disjunctions by children in English (see Tieu et al., 2017 for French, German and Japanese). The two approaches offer accounts of phenomena that are usually considered to be a language performance error in child language, as the result of a sophisticated and legitimate inference mechanism (with adults, Mascarenhas, 2014 discusses the general program of sorting reasoning 'errors' and legitimate inferences).

2.2 More empirical data points

We cannot review all existing accounts of q-spreading: the issue has been attributed to numerous domains such as the syntax or syntax-semantics interface (e.g., Roeper and de Villiers, 1991, Philip, 1995, Drozd and van Loosbroek, 1998, Geurts, 2003), performance (Crain et al., 1996) or problems with cognitive resources and shallow processing (Freeman et al., 1982; Brooks and Sekerina, 2006). Most of these however agree in that they locate the problem in the universal quantifier (its syntax, semantics, or complexity). The account we describe (hereafter implicature account) does not and is thus a distinct option which ought to be evaluated in depth. The implicature account of q-spreading also has another simple merit: a full account of children's grammar is fully obtained, simply as the typical account already motivated for adults, the explanatory load is in fact moved away from the question of why children have q-spreading to why adults don't. Let us thus review how this account connects with empirical knowledge on the topic more broadly.

2.2.1 Developmental path

Aravind et al. (2017) conducted a longitudinal study in which children were tested four times between ages 4-7. They found that, at first, children showed little q-spreading, but that the amount of q-spreading errors increased with each subsequent testing (unlike in Philip and Takahashi, 1991). Such developmental path is well-explained if q-spreading is the result of implicatures, and if the rate of implicatures increases with age, as suggested by the low rate of derivation by young children (Noveck, 2001, a.o). This U-shape trajectory is difficult to accommodate under accounts which blame limited cognitive resources and processing for q-spreading (for instance, Brooks and Sekerina, 2006).

2.2.2 Contextual effects

It has been noticed that certain manipulations of experimental context can significantly reduce the amount of q-spreading (Crain et al., 1996; Philip, 2011).[2] An implicature account

[2]Philip (2011) reports that what is considered to be a topic in the experimental context can have an influence on q-spreading. When the topic surrounding the experimental question is about the subject noun, there is less q-spreading than when the topic is about the indefinite noun. Crain et al. (1996) on the other hand worried about

of q-spreading has the potential to capture this context dependency too, since context naturally influences the derivation of implicatures. Appendix C reveals one way in which context dependency can be observed in the adult counterpart of q-spreading, that is in distributive inferences with disjunction. This gives further credit to the idea that q-spreading and distributive inferences have much in common.

2.2.3 Superficially similar errors: unify the account?

Similarly, one may wonder whether q-spreading, also called type A error, is similar to other types of "errors" children make with universally quantified sentences. Children makes other errors with sentences such as (4a), and the implicature account is only able to explain q-spreading. But the other relevant errors show differences with q-spreading which may justify a separate account.

First, children seem to accept (4a) when not every girl took an apple, but all of the apples in the image were taken. But these errors (type B) have been shown to have different developmental trajectories than q-spreading. In the aforementioned study by Aravind et al. (2017), with each subsequent testing children made fewer type B errors, but showed more q-spreading.

Second, children may reject (4a) when every girl took an apple, but the image also displays, for instance, a boy who took a banana. This type of error, called type C error or the perfectionist response, seems to be the least common of the three types of errors and restricted to very young children (Geurts, 2003), which suggests that q-spreading is of a different nature than type C errors as well.

2.2.4 The role of the indefinite

The current account locates the issue in the presence of the indefinite, and therefore does not make predictions in the absence of an indefinite (or an alternative trigger). However, the literature focussed almost exclusively on how children interpret sentences with indefinite noun phrases in the scope of a universal quantifier. If q-spreading was consistently found without indefinites, the implicature account would have to justify that children could think that some elements, like indefinites, also trigger disjunction-like alternatives.[3]

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the felicity of test sentences in a static picture truth value judgment task — according to Crain, test sentences should be presented in a context in which up to a certain point their truth is undetermined. In their experiment, before presenting the universally quantified test sentence, such as 'Every skier drank a cup of cider.', children were played out a story in which the skiers were discussing whether to take a cup of cider or a bottle of soda. Some of the skiers would immediately opt for a cup of cider, while one of the skiers would hesitate between the two. This is, according to Crain, the crucial point for the felicity of the test sentence, because, depending on what the hesitating skier decides, the sentence could end up being either true or false. With this manipulation, the amount of q-spreading in children decreased.

[3]Inhelder and Piaget (1964) reported that children may reject sentences like *All the circles are blue* in a situation in which all the circles are blue but there are also blue squares. Philip and Takahashi (1991) and Takahashi (1991) showed some degree of q-spreading (i) with indefinites, (ii) with transitive sentences with null objects, as in *Every boy is driving*, saying false when some car has no driver, and (iii) with intransitive sentences like *Every dog is sleeping*, saying false when there are some extra beds in which no dog is sleeping. But the effect was more or less strong in the different cases, and one may always say that a null indefinite may be hidden. More systematic investigations could tell whether a unified account of these responses with

Conversely, the implicature account makes systematic predictions when an indefinite is present: children should have q-spreading effects with indefinites, whenever adults have q-spreading-like effects with disjunctions. This is unlike existing accounts of q-spreading which may locate the problem in the universal quantifier and not in the indefinite. One could thus systematically compare the interpretation of an indefinite for children and of disjunctions for adults in new environments, such as the scope of modals and quantifiers other than universal. In particular, there are data suggesting that it does not occur with definite subjects (Drozd, 2001), and one can find at least indirect reports of tests of sentences headed by other determiners such as *both* or cardinal determiners (Takahashi, 1991; Roeper et al., 2011). At this point, it is fair to say that more systematic tests would be informative, with indefinites in various environments and with the new view that q-spreading effects may take the specific form discussed here, i.e. distributive inferences (and not, e.g., inversion).

2.2.5 Non-dominant languages

One challenge for the implicature account comes from q-spreading errors recently found in heritage speakers (Sekerina and Sauermann, 2015) and second language learners (Berent et al., 2009). If these are to be explained in the same fashion as children's q-spreading, the implicature account would have to assume that these populations have not perfectly acquired in their heritage/second language whatever turns out to be responsible for differences between disjunctions and indefinites in the scope of a universal quantifier (but they have acquired this in their dominant/first language). To assess this possibility, one would need a more precise account of this difference with adults to begin with. We turn to this in the next section, but without providing an answer to the heritage/second language puzzle for the implicature account.

3 Challenges and directions concerning adults and children

One major question that stems out of the implicature theory of q-spreading is what precisely differs between adults and children, and why adults don't have q-spreading with indefinites to begin with. In some sense, semanticists and children seem to agree on their analyses of the adult data. We discuss here the challenges they face and possible solutions.

3.1 Free choice effects and what they reveal about disjunctions and indefinites

A first possibility is that both children and semanticists are mis-analyzing free choice effects. The major argument for assuming similar sets of alternatives activated by indefinites and disjunctions is their parallel behavior in terms of free choice inferences ((1) and (3)). But it may be wrong to try to derive free choice effects in the same way for indefinites and disjunctions and while disjunctions may activate domain alternatives in adult language, indefinites might not. This would explain why adults do not have q-spreading, but it would also require a new account for free choice effects, at least for indefinites. If this turns out to be correct, what could be happening in child language is that children are mistaken in a similar way as semanticists: given how similar interpretations of disjunctions and indefinites

q-spreading is justified (see also section 2.2.3 for other types of errors children make with universally quantified sentences, but arguably then with different properties).

are in many environments, children might start off assuming that they are virtually identical, and in particular that they activate similar alternatives.

Interestingly, a most recent account proposes a slight modification of how free choice inferences may be obtained: Bar-Lev and Fox (2017) make it possible to derive free choice effects from singleton alternatives of the form P(A_x), and without P(A_{x_1} or A_{x_2} or ...) alternatives, although the latter would still be needed for distributive inferences. If this is correct, the subtle difference between indefinites and disjunctions, hard to track for both children and semanticists, would be the absence of the latter kind of alternatives for indefinites, and their presence for disjunctions. These alternatives make sense though in terms of their complexity relative to that of the sentence: indefinites are simple and activate singleton alternatives, disjunctions may be more complex and activate sub-parts of themselves as alternatives. This is a very promising direction to explore, and it may eventually lead to a confirmation of Bar-Lev and Fox's approach. This requires a more in depth analysis of what and how free choice effects and distributive inferences are predicted (see Crnič et al., 2015 for desiderata). The major empirical challenge from the current perspective would probably be to explain q-spreading effects in non-dominant languages (see section 2.2.5). For now, we turn to an evaluation of the difficulties for more classic accounts.

3.2 Blocking q-spreading effects for adults, the example of intervention effects

Semanticists and children may be missing a piece of adult grammar that blocks the distributive inferences with indefinites for adults. This piece of grammar would be missed by children for lack of evidence up to a certain age or for lack of the competence needed to deploy it (and maybe L2 speakers also lack the ability to recruit the relevant resources). Let us see what this piece of grammar could be like.

To account for a puzzle concerning the licensing conditions of the NPI *any* Chierchia (2013), p.195 proposes that *every* creates intervention effects: in a configuration such as (5), the alternatives of the negative polarity item cannot be exhaustified, and, by assumption, this makes the negative polarity item ungrammatical in the scope of *every*.

(5) *[*exh* [every [any]]]

The absence of q-spreading with indefinites in adult language may be the same type of situation: the universal quantifier creates intervention for the exhaustification of the alternatives of indefinites in the same position as *any* above, and therefore implicatures for sentences such as (4a) would be blocked. However, as already mentioned, adults do have q-spreading with disjunctions (aka distributive inferences, see Appendix B). To the extent that this phenomenon results from exhaustification, this exhaustification happens within the same syntactic configuration as in (5), with the disjunction occupying the position of *any*. Hence, the universal quantifier is not intervening for all elements which activate alternatives and which are in its scope: it is not intervening for the exhaustification of disjunction, and this selectivity of intervention would have to be explained.[4]

[4]Perhaps the universal quantifier intervenes only when the element which activates alternatives is of some type, surely *any* and indefinites are more similar with one another than they are to disjunctions. But note that

If the implicature account of q-spreading in child language is correct, then the difference between children and adults would be that children are not sensitive to intervention effects. It seems to us that this account involves many non-trivial pieces. But it has the virtue of being testable: children (and L2 learners) might accept polarity items in the scope of the universal quantifier, at least to the same extent that they show q-spreading effects.

4 Conclusion

Given current assumptions on the similarity of alternatives activated by indefinites and disjunctions, the fact that disjunctions, but not indefinites, trigger domain implicatures in the scope of the universal quantifier is puzzling. We have proposed that even if current semantic theories turn out to be incomplete for adults, they may be entirely correct for children, then, with q-spreading effects revealing the expected presence of domain implicatures. We discussed essentially two possibilities for the difference between children and adults: (i) children and semanticists are both wrong to assume that indefinites activate the same alternatives as disjunctions, (ii) indefinites do activate the same alternatives as disjunctions in child language, but children are missing a piece of adult grammar that blocks some of their effects.

Appendix

In three experiments we show that children behave with indefinites (showing q-spreading effects) like adults do with disjunctions (deriving distributive inferences): full data and analyses are available online at `https://tinyurl.com/ya8w4gyo`.

Appendix A: Experiment 1

First, we demonstrate that adults do not show q-spreading effects with indefinites. Participants judged some q-spreading sensitive sentence such as (4a) as 'True', 'False', 'Neither'[5] with respect to three types of image. FALSE: the sentence was literally false (some girl did not take any apple), TRUE: the sentence was true (all girls took an apple) and all apples were taken, TARGET: the sentence was true (all girl took an apple), but crucially some apple was not taken (q-spreading). We varied the total number of apples (2 or 3 for FALSE, 3 or 4 for TRUE, and 4 or 5 for TARGET), whether or not there was a girl who took more than one apple, and apple color (red and green), for a total of 36 items. In the target condition, 'Neither' or 'False' responses (to a larger extent than in other conditions) would be indicative of distributive inferences.

45 participants were recruited on Amazon Mechanical Turk, 3 of them were excluded from the analysis for giving more than 25% incorrect responses in true and false conditions. Generalized mixed effects linear regression model were fitted to the responses for TRUE

items like 'some' do trigger implicatures when in the position of *any* in configurations such as (5), so one would need to explain a broader pattern: the universal quantifier intervenes with *any* and indefinites, but not disjunctions and *some*.

[5] 'Neither' was a response option to accommodate people who derive distributive inferences, but would not go so far as to say that the sentence is false because of them. Overall, there were very few 'Neither' responses. They were collapsed with 'False' responses for the analysis.

and TARGET conditions with and without the condition as a fixed effect, and random by-participant intercepts and slopes (the maximal random effect structure for which convergence was achieved). The comparison did not reveal a significant effect of condition: $\chi^2(1) = 0.08, p = .76$ (cf. Figure 2, indefinite (left-most) panel): no evidence for q-spreading effects were found with indefinites in adults.

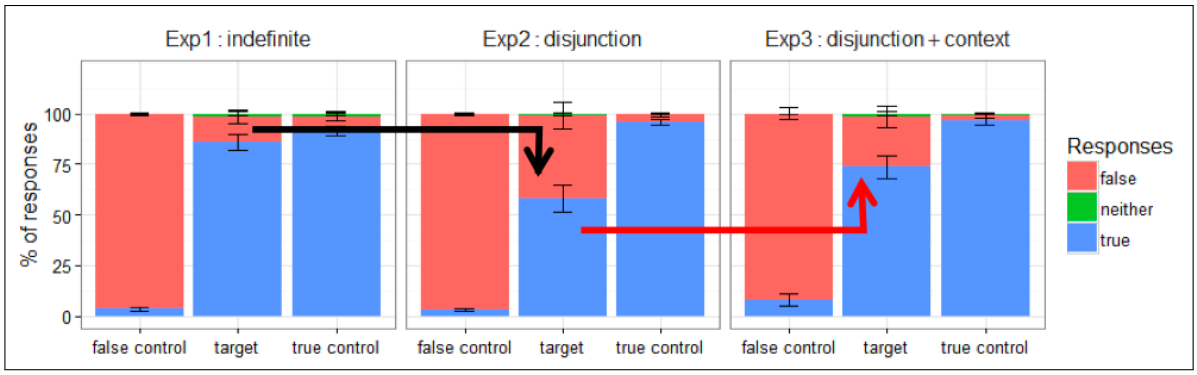

Figure 2: Distributive inferences can be measured as the proportion of false responses to the target condition (or more precisely as the increase of such responses compared to the baseline rate observed in adjacent true controls). The Figure represents adults' responses to universal sentences with an indefinite, with a disjunction, with a disjunction in the presence of additional contextual manipulation. Distributive inferences are absent in Exp. 1, they appear in Exp. 2 (black arrow), and they are also present in Exp. 3, but to a lesser extent (red arrow).

Appendix B: Experiment 2

Second, we show that simply replacing indefinites with disjunctions reveal q-spreading like effects with adults. The experiment was thus similar except that the indefinite in the sentence (cf. (4a)) was replaced with a disjunction, as in (2a).

46 other participants were recruited on Amazon Mechanical Turk, 4 were excluded from the analysis for their low scores on controls, as before. Mixed-models comparisons revealed a significant interaction between condition (target vs true) and experiment (indefinite vs disjunction): $\chi^2(1) = 11.0, p < .001$, thus showing that disjunctions make distributive inferences/q-spreading effects observable.

Appendix C: Experiment 3

Finally, we evaluate whether distributive inferences are sensitive to similar contextual manipulations as q-spreading effects with children (e.g., Crain et al., 1996; Philip, 2011, a.o.). Very much following Hollebrandse, 2004; Philip, 2011 who found that the q-spreading is reduced with children when the topic is about the noun in the restrictor of the universal quantifier, we manipulated the relative salience of the subject and object, with the idea that putting salience away from the object should reduce the effect of its alternatives, and hence

q-spreading/distributive inferences. We did so with the following changes from Experiment 2: (i) the object was kept constant (i.e. boring) by keeping the same number of apples (=4) across trials and accordingly the same linguistic disjunction in the sentence, (ii) the subject was made more varied: the noun would now be either *girl* or *boy* and, in new filler sentences, the quantifier could be *exactly two*, *not every*, and *more than two*. The main changes were thus that there were (irrelevant) items in Experiment 3, for a total of 96 items (with only 24 items with the universal quantifier in subject position).

45 participants were recruited on Mechanical Turk to do the task, 6 excluded using the same criterion as above. Mixed-models comparisons revealed a significant interaction between Condition (target vs true) and (i) Experiment (1 vs 3): $\chi^2(1) = 26.7, p < .001$, but also (ii) Experiment (2 vs 3): $\chi^2(1) = 4.40, p = .036$, thus showing that (i) distributive inferences/q-spreading effects exist but (ii) are weaker with the current contextual manipulation (red arrow in Figure 2).

Given that distributive inferences are instances of implicatures, that their rate of derivation be sensitive to contextual manipulations is not surprising. But these results open the way for a more substantial claim: a similar mechanism may be behind both the effect we observe in Experiment 3 and the reduction of q-spreading observed in experiments with children: the lower salience of the alternatives of disjunctions (for adults) or indefinites (for children).

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