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Number Agreement of Coordinated Subjects: Competing Syntactic and Semantic Rules

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Abstract
We investigate number agreement in coordinated subjects, including disjunctions and conjunctions of singular universal quantifier. Experimental data from German reveals that they often allow for singular agreement. We argue that there is a competition between semantic and syntactic agreement, and that the latter is a generalization of the former.

Keywords: agreement, number, singular, plural, coordination, disjunction, quantifiers

1 Number agreement: Syntactic vs. semantic?

The present work contributes to our understanding of the nature of agreement by considering number agreement of coordinated subjects with the finite verb, with German as the language under consideration. It targets the question whether agreement is a formal, syntactic phenomenon, or is triggered by semantic content.

On first inspection, subject-verb number agreement appears to be a purely morphosyntactic rule. This explains cases like *The rice is in the jar* vs. *The grains of rice are in the jar*, as well as *The furniture is on the truck* vs. *The pieces of furniture are on the truck*. Furthermore, we say *the scissors are in the drawer* even when referring to only one pair of scissors. The morphosyntactic arbitrariness becomes apparent when comparing agreement across languages. In German, *Möbel* 'furniture' is a plurale tantum noun and hence triggers plural agreement (*Die Möbel sind auf dem Lastwagen*) whereas *Schere* 'pair of scissors' is a regular count noun, triggering singular agreement (*Die Schere ist in der Schublade*).

However, there is also evidence for conceptual, or notional principles behind number agreement. One well-known example is that in British English, in contrast to American English, collective nouns referring to groups or organizations allow for plural agreement even in case they are syntactically singular, as in *The management is / are not responsible*. Bock et al. (2006) argue, based on experimental evidence, that the agreement rule of speakers of British English is not directly sensitive to the denotation of subjects. but that collective nouns like

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management, *team* and *family* have plurals that are identical to their singular forms, and hence plural agreement is syntactic in nature as well. Corbett (2023), on the other hand, argues for genuine semantic agreement.

When we look at gender agreement, there are many well-known instances in which the denotation of the referent determines agreement, overriding the lexically assigned formal gender. Well-known cases of such mismatches are German *Mädchen* 'girl' and *Weib* 'woman, wife', which are morphosyntactic neuter but denote female humans and can trigger semantic, feminine agreement. Semantic agreement is easier for constituents that are lower on the agreement hierarchy identified by Corbett (attributive modifier > predicate > relative pronoun > personal pronoun); cf. Corbett 2023 for recent discussion, and Fleischer 2012 for historical developments. This is perhaps not surprising, as personal pronouns are referential, and hence should be more influenced by the properties of their denotation than attributive modification or predication.

2 The case of coordination

One instance of semantic agreement appears to be cases with subjects consisting of a conjunction of two singular DPs that agree with plural predicates:

(1) [[*the boy*]$_{SG}$ *and* [*the girl*]$_{SG}$] [**is*$_{SG}$ / *are*$_{PL}$ *in the kitchen*]]

A syntactic account of plural agreement faces the problem to explain plural agreement in such cases: In terms of feature projection, we expect singular agreement. We would be less surprised about plural pronouns in subsequent discourse as in (2), as reference is clearly to two persons, leading to semantic agreement.

(2) ... *They*$_{PL}$ *had found the peanut butter.*

Why we have plural in predications like (1) is a well-known problem. For example, Peterson (1986) proposed that conjunction blocks feature percolation so that the conjoined DP does not have any number feature, as illustrated in (3) with DPs referring to substances. The agreeing predicate is free to choose any number feature, and is doing this following semantic principles: In case of singular agreement as in (b), it is a predication about a mixture of substances; in case of plural agreement as in (c), it is about a plurality of substances.[2] Peterson assumes that the number feature of the predicate imposes itself on the number of the subject.

[2] The effect of the mixture vs. plurality of substances can be checked by corpus searches. Google ngram data reveal that conjunctions of mass nouns that are likely interpreted as mixtures trigger plural less frequently than those that are less likely interpreted as mixtures (*oil and vinegar are* 1.5x *oil and vinegar is*, *salt and pepper are* 2x *salt and pepper is*, *tea and coffee are* 4x *tea and coffee is*, and *salt and sugar are* 4x *salt and sugar is.*

(3) a. [[*peanut butter*]SG *and* [*jam*]SG]Ø
b. [[[*peanut butter*]SG *and* [*jam*]SG]SG [*is*SG *good*]]
c. [[[*peanut butter*]SG *and* [*jam*]SG]PL [*are*PL *good*]]

As we have seen, Peterson invokes a semantic dimension of plural agreement that resides in the predicate: predication on mixtures vs. predications on pluralities. Huddleston et al. (2002) discuss coordination of count nouns with the examples in (4), with a distributive (a) vs. a quantity-denoting interpretation (b).

(4) a. *Two ham rolls and a glass of milk were hidden behind the lamp.*
b. *Two ham rolls and a glass of milk was more than she wanted.*

Considering another case of coordination, disjunction, we find that both singular and plural agreement are acceptable:

(5) [[*the boy*]SG *or* [*the girl*]SG] [*is*SG / *are*PL *in the kitchen*]

Foppolo & Staub (2020) discuss possible semantic conditions for singular vs. plural agreement in disjunctions. For example, they entertain the possibility that plural agreement signal the availability of inclusive readings. However, based on experimental evidence, they dismiss this possibility. Himmelreich & Hartmann (2023) provide experimental evidence for the optionality of singular vs. plural agreement in such cases in German, and propose that it is the result of a tie of grammatical constraints, resulting in effect in two parallel grammars. Hence, in the case of disjunction, the choice between singular and plural agreement does not appear to be related to semantic distinctions.

3 Conjunction of quantifiers

So far, we have discussed coordinations with singular referring DPs like *the boy*. However, it has been observed by Hoeksema (1983) that things may be different with conjunctions of singular quantifiers, which allow for singular agreement:

(6) a. [[*every day*]SG *and* [*every night*]SG] [*was*SG *spent in bed*]
b. [[*every man*]SG *but* [*no woman*]SG] [*was*SG *upset*]
c. [[*no peasant*]SG *and* [*no pauper*]SG [*was*SG *ever president*

The issue is of some public concern. Searching for the terms “every boy and every girl is” + “subject” + “verb” leads to a number of entries on web sites like “Quora”[3] “English for students”[4], “English language & usage”[5] and “Brain.ly.”[6]

[3] https://www.quora.com/Is-it-every-boy-and-girl-and-every-man-and-woman-has-or-have-come
[4] http://www.english-for-students.com/Subject-and-Verb-agreement.html
[5] https://english.stackexchange.com/questions/268045/is-the-phrase-every-x-and-every-y-singular-or-plural
[6] https://brainly.in/question/43307532

The standard grammar of German also observes a distinct agreement pattern for quantifiers. *Duden: Die Grammatik* (1998: 1295) states that with conjunctions based on *jeder* 'every', *kein* 'no' and *mancher* proportional / distributive 'some', we find typically singular agreement, but that plural agreement is possible as well. The 2006 edition (1017) recommends singular agreement in these cases, whereas *Duden: Zweifelsfälle* (2007: 551) allows for singular or plural agreement. It states that bare quantifiers allow only for singular agreement:

(7) [[*jeder*]$_{\text{MASC.SG}}$ *und* [*jede*]$_{\text{FEM.SG}}$] [*fühlte*$_{\text{SG}}$ / **fühlten*$_{\text{PL}}$ *sich wohl*]
'every male and every female felt well'

The only empirical investigation of this issue that we know of is the dissertation by Wegerer (2012), who included one sentence in her questionnaire about number agreement in German. The 2098 participants were presented with a forced choice between singular and plural agreement for the following sentence; singular *kann* was generally preferred (73%) over plural *können* (27%).

(8) *Jeder Ehemann und jede Ehefrau kann / können darüber selbst entscheiden.*
'Every husband and every wife can decide on that him-/herself.'

The following section reports on a more comprehensive rating experiment on subject-verb agreement of with coordinated subjects that contain singular referential DPs as well as quantified DPs.

4 Coordination of referring expressions and quantifiers: Experiment

We investigated agreement patterns with coordinations systematically in a rating study. Our main interest was in differences of verb agreement with respect to conjoined referring definite DPs (D&D) and conjoined universally quantified DPs (Q&Q). As agreement is known to be sometimes partial to one of the coordinates, we also investigated mixed conjunctions (D&Q and Q&D). Furthermore, we looked into disjunctions of referring DPs in the same setup (D∨D). After having carried out the experiment, we also investigated conjunctions of the type 'both… and…' for referring DPs (D∧D).

The experiment was carried out for German on the online recruiting platform Clickworker. The experimental items were mostly presented as filler items in another rating study (Krifka & Modarresi 2023). We recruited 133 participants that rated 7 experimental items presented in one of 6 different lists, with two versions per list. The task was to rate items on a Likert scale from 1 (very good) to 5 (very bad). We asked participants to give us judgements about how correct they thought the sentence sounded. Each participant rated an item only under one condition (SG or PL agreement), so direct comparisons of SG and PL agreement as in Wegerer (2012) were avoided. In (9) we present the experimental items in one of six lists.

(9) D&D *Der Student und die Dozentin hat / haben die Sendung über den Klimawandel angeschaut.* 'The student and the lecturer watched the feature about climate change'

DVD *Der Mieter oder der Gast hat / haben einen Geruch in der Küche wahrgenommen.* 'The tenant or the guest noticed a smell in the kitchen'

Q&Q *Jeder Student und jede Studentin hat / haben einen Brief von der Universität erhalten.* 'Every male student and every female student received a letter from the university'

D&D *Der Verkäufer und die Kundin hat / haben einen Dieb am Obststand beobachtet.* 'The sales person and the customer observed a thief at the fruit stand.'

Q&D *Jeder Tourist und die Reiseleiterin hat / haben ein Freigetränk bekommen.* 'Every tourist and the tour guide got a free drink.'

DVD *Der Mittelstürmer oder der Verteidiger hat/ haben ein Foul begangen.* 'The center forward or the defender committed a foul.'

D&Q *Die Erzieherin und jedes Kind ist über eine Hängebrücke gegangen.* 'The teacher and every child went over a hanging bridge.'

We also tested two filler items that contain a violation of auxiliary choice as a control item for a severe grammatical violation.

(10) a. *Der Pianist und der Posaunist *sind* (ok: *haben*) *den Einsatz verpasst*. 'The pianist and the trombonist missed the entry'

b. *Der Hausmeister und der Passant *sind* (ok: *haben*) *den Unfall an der Ecke bemerkt.* 'The caretaker and the passer-by noticed the accident at the corner.'

Due to the use of the items as fillers to another experiment, the number of judgements for the items were different; they ranged from 27 for D&Q SG to 158 for D&D PL with an average of 83 items per condition. In an additional experiment, also as a filler item of another rating experiment, we recruited 88 participants to rate one sentence with the conjunction *sowohl… als auch…* 'both… and…':

(11) DVD *Sowohl der Verkäufer als auch die Kundin hat / haben einen Dieb am Obststand beobachtet.* 'Both the salesperson and the customer noticed a thief at the fruit stand.'

Table 1 presents the results of the rating experiment, where the bar charts are centered around the averages. Please be aware that the calculation of averages is not fully justified, as the rating results in ordinal data, not interval data.

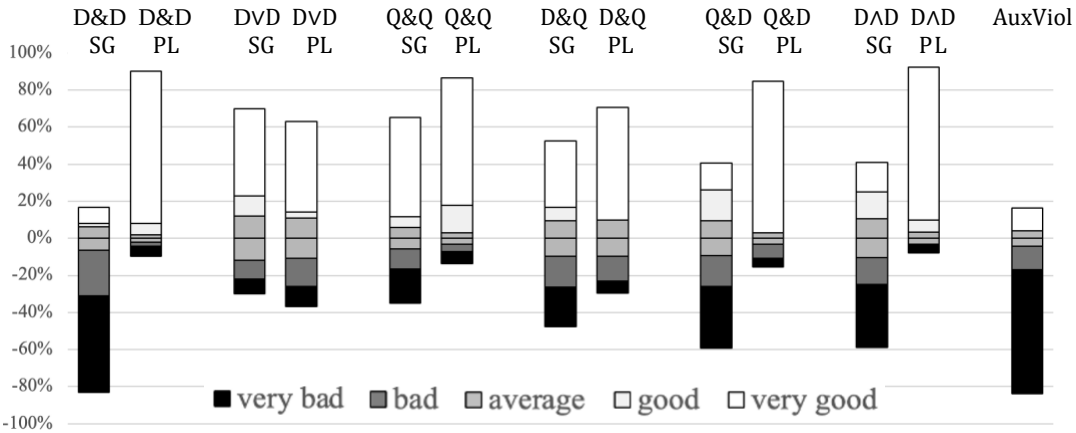

Table 1: Acceptability ratings of SG and PL verb agreement with coordinated subjects, where D: referential singular DP, Q: universally quantified DP, &: 'and', ∨ 'or' and ∧ 'both… and…' AuxViol: Control item, auxiliary violation.

As for statistical significance, the Wilcoxon signed-ranked test for non-parametric data could not be applied systematically, as we did not have full data sets for participants (recall that the experimental items were filler items to another experiment). But polling "very good" / "good" and "bad" / "very bad" ratings and applying a chi-square test, we find that there is a significant difference between, e.g. D&D SG and Q&D SG ($p < 0.001$). There are no significant differences for PL agreement between D&D, Q&Q, Q&D and D∧D; however, the difference between D&D PL and D&Q PL reaches the $p < 0.01$ level. For each of the agreement cases, PL was significantly better than SG (e.g. Q&Q SG vs. Q&Q PL: $p < 0.01$). Our results differ from the forced-choice experiment for Q&Q of Wegener (2012), where a preference for singular forms was recorded. The exception is disjunction D∨D, where PL agreement was insignificantly better than SG agreement (a similar result as with Himmelreich & Hartmann (2023), who employed a Likert scale from 1 to 4, and also investigated the influence of the order of subject and verb, and closest conjunct agreement. The Wilcoxon signed-ranked test could be applied to D∨D SG vs. PL, showing no difference.

We want to point out the order sensitivity that appears to shop up with the D&Q and Q&D cases. While the difference between D&Q SG and Q&D PL is not significant ($p \approx 0.2$), nor is the difference between D&Q PL and Q&D PL ($p \approx 0.1$), there is an interaction: Q&D SG is rated worse than D&Q SG, but Q&D PL is rated better than D&Q PL (cf. section 5.10 for further discussion).

While the experiment delivered interesting and interpretable results, we would like to stress that it is preliminary and should be replicated, for German and for other languages, in a design that targets these issues directly. Important issues that the current setup does not answer are: (i) Are there individual preferences of

speakers for particular agreement patterns? (ii) Does the agreement pattern vary with the animacy of the noun and semantic properties of the verb, like agentivity? (iii) For German, bare quantifiers like *jeder und jede* 'every.MASC and every.FEM' are said to have a stronger preference for singular agreement; this should be checked. (iv) Agreement patterns with DPs based on the quantifiers *kein-* 'no' and *manch-* proportional 'some' should be investigated. (v) Agreement patterns with postverbal subjects are of interest, especially for the D&Q case and the Q&D case

5 Interpretation and Modelling

In the following subsections, we will have a closer look at the individual cases and develop a semantic and syntactic modelling. We generally use English examples, to simplify the discussion. While there are good reasons for assuming that experiments on English would result in similar findings, this should be kept in mind.

5.1 Semantic ingrediencies of plurality

We will make use of the convention that meanings of expressions α are rendered as ⟦α⟧, which are given in an extensional form, e.g. ⟦*girl*⟧ = the function that assigns truth to x if x is a girl, else falsity, rendered as λx[x is a girl], or G in short.

The semantic aspects of the singular / plural distinction are modelled by sum individuals. We assume a sum operation ⊔ on entities, where x⊔y is the sum of x and y, with part relation ⊑ defined as y⊑x iff x⊔y = x (cf. Champollion & Krifka 2016 for an overview). We write AT(x) to express that x is an atom, that is, x does not have proper parts: AT(x) iff ¬∃y[y⊑x ∧ y≠x]. We also assume a predicate AT for predicates P that holds if and only if all entities that P applies to are atomic: AT(P) iff ∀x[P(x) → AT(x)]. The sum operation can be generalized to predicates; we write ⊔P for the smallest P′ such that ∀x[P(x) → P′(x)] and ∀x,y[P′(x) ∧ P′(y) → P′(x⊔y)]. That is, ⊔P is P closed under sum formation. To render the definite article, we introduce the notation ιP, defined as the unique x such that P(x) and ∀y[P(y) → y⊑x] hold. Notice that if AT(P), then ιP is defined if and only if P applies to exactly one entity, i.e. ∃x[P(x) ∧ ∀y[P(y) → x=y]].

For a semantic theory of singular predicates it appears natural to require that they apply to atomic entities, expressed by a presupposition, e.g λx:AT(x)[G(x)] for the singular *girl*. But mass nouns like *water* are singular as well but are not restricted to atomic entities. We assume for the purpose of this paper that the semantic singularity of a predicate signals that it cannot apply to entities that consist of distinct atoms. We introduce a predicate SSG that holds of an entity if it does not consist of two or more atoms, defined as SSG(x) iff ¬∃y∃z[z⊑x ∧ z⊑x ∧ AT(y) ∧ AT(z) ∧ y≠z]. We also assume that substances like the stuff referred to be *water* do

not have atoms in natural-language ontology, hence if x is water, we also have SSG(x). Other approaches are possible, but this will do for our purposes.

5.2 Agreement of non-coordinated subjects

We start out with the notion that subject-predicate number agreement is semantic. This means that the singular form of the predicate (for which we simply assume a syntactic category PRED, and do not care about the internal construction of its meaning) comes with a presupposition that it applies to atomic entities only. The following example shows that the singular predicate *is in the kitchen* (whose meaning is rendered by K) can be applied to the definite term based on *the girl* (G):

(12) ⟦[[$_{DP}$ *the girl*]$_{SG}$ [$_{Pred}$ *is in the kitchen*]$_{SG}$]⟧
= ⟦[$_{Pred}$ *is in the kitchen*]$_{SG}$⟧(⟦[$_{DP}$ *the girl*]$_{SG}$⟧)
= λx. SSG(x) [K(x)](ιG)
= K(ιG), as SSG(x) is satsified, due to AT(G), provided there is a unique girl.

As evident from (12), we assume that the singular predicate *is in the kitchen* comes with a presupposition (a semantic restriction) to semantically singular predicates. We furthermore assume that the meaning of *girl*, G, is atomic, AT(G), hence ιG will refer to a single atom. This satisfies the semantic requirement of SSG.

For the plural form of the predicate, we assume an operation of closure under sum formation, which does not have a restriction to atomic entities. There are theories that assume that plural is semantically unmarked, and that pragmatic rules determine when singular and plural forms are used (cf. e.g. Sauerland 2003). We do not go into this issue and, for ease of exposition, assume that plural restricts a predicate to entities x that satisfy ¬SSG.

(13) ⟦[[$_{DP}$ *the girls*]$_{PL}$ [$_{Pred}$ *are in the kitchen*]$_{PL}$]⟧
= ⟦[$_{Pred}$ *are in the kitchen*]$_{PL}$⟧(⟦[$_{DP}$ *the girls*]$_{PL}$⟧)
= λx. ¬SSG(x) [K(x)](ι[λx.¬SSG(x)[⊔G(x)]])
= [K(ι[λx.¬SSG(x)[⊔G(x)]])], as SSG(x) can be satisfied,
as ι[λx.¬SSG(x)[⊔G(x)]] is a sum individual of two or more atoms.

The form **the girl are in the kitchen* is ruled out, as *the girl* refers to an atom, violating the ¬SSG constraint, cf. (14). The form **the girls is in the kitchen* is ruled out as well, as *the girls* refers to an entity consisting of at least two atoms, violating the SSG constraint, cf. (15).

(14) ⟦[[$_{DP}$ *the girl*]$_{SG}$ [$_{Pred}$ *are in the kitchen*]$_{PL}$]⟧
= λx. ¬SSG(x) [K(ιG)]
undefined, as ¬SSG(ιG) is false

(15) ⟦[[$_{DP}$ *the girls*]$_{PL}$ [$_{Pred}$ *is in the kitchen*]$_{SG}$]⟧
= λx. SSG(x) [K(x)](ι[λx.¬SSG(x)[⊔G(x)]]),
undefined, as SSG(x)(ι[λx.¬SSG(x)[⊔G(x)]]) is false.

The semantic rules tell us that sentences like *The girl are in the kitchen* and *the girls is in the kitchen* are systematically undefined, and this can be taken to be a reason for their perceived ungrammaticality (cf. Abrusan 2019 for recent discussion) for the relation of semantic violations and ungrammaticality.

We get exactly the same result with the syntactic agreement rule (16). That is, The semantic rule and the syntactic rule give us the same result:

(16) Syntactic agreement: In a structure [[$_{DP}$ …]$_{NUM:\alpha}$ [$_{PRED}$ …]$_{NUM:\beta}$],
the number features α and β have to be identical (both SG, or both PL).

Let us now turn to conjunction of DPs, the main topic of this article.

5.3 Conjunction of two referring DPs: D&D

We have seen that the conjunction of two referring DPs triggers plural agreement. We can motivate this by semantic agreement, if we interpret conjunction, *and*, by sum formation, ⊔:

(17) ⟦[[[$_{DP}$ *the boy*] *and* [$_{DP}$ *the girl*]] [*are in the kitchen*]$_{PL}$]]⟧
= ⟦[*are in the kitchen*]$_{PL}$]]⟧(⟦[[$_{DP}$ *the boy*] *and* [$_{DP}$ *the girl*]]⟧)
= λx.¬SSG(x) [K(x)]([ιB⊔ιG])
= K(ιB⊔ιG) as ¬SSG([ιB⊔ιG]) is satisfied

The expression *the boy and the girl*, if it refers at all, picks out an individual consisting of two atoms, provided that *the boy* and *the girl* refer to distinct individuals. This satisfies the predicate condition ¬SSG, and hence the resulting semantic representation is defined. In contrast, a singular predicate is ruled out:

(18) ⟦[[[$_{DP}$ *the boy*] *and* [$_{DP}$ *the girl*]] [*is in the kitchen*]$_{SG}$]]⟧
= λx.SSG(x) [K(x)]([ιB⊔ιG])
undefined, as ¬SSG([ιB⊔ιG])

The condition would not hold if the two conjuncts refer to the same entity, as as x⊔x = x. However, this would be pragmatically odd due to Grice's maxim of manner (Grice 1975), as the conjunction would be superfluous. In cases like *I discovered that my father's great-grandfather and my mother's great-great-uncle is / are the same person*, both possibilities arise[7], which could be modelled by either an extensional interpretation with singular agreement, or an intensional interpretation with plural agreement.

[7] https://ell.stackexchange.com/questions/103632/are-the-same-person-or-is-the-same-person

It has been observed that sometimes ambiguities arise, as in (19), modelled after an example of Brehm & Bock 2013.

(19) a. *Her cousin and best friend* was / *were present at the wedding*.
b. *Her cousin and her best friend* **was* / *were present at the wedding*.

Example (a) refers to one or two persons, as reflected in the number agreement. This is due to an ambiguity of the subject, *her cousin and best friend*, which has a reading involving NP conjunction, [$_{DP}$ *her* [$_{NP}$ *cousin and best friend*]] In unambiguous DP conjunctions as in (b), only the plural interpretation is acceptable.

5.4 Conjunction of two universally quantified DPs: Q&Q

Turning to singular universal quantified DP, we observe that there is no immediately obvious way to make them denote a sum individual. The reason is that $\sqcup$ is defined for entities, not for quantifiers (but see section 5.9). This contrasts with the plural DP *all girls*, which may be represented by the join $\sqcup$G, the sum individual consisting of every x for which G(x) holds. The standard way of representing universal quantifiers is by second-order predicates (cf. Montague 1973, Barwise & Cooper 1981), leading to derivations as in (20):

(20) $[\![[[_{DP}$ *every boy*$]_{SG}$ [*is in the kitchen*$]_{SG}]]\!]$
$= [\![[_{DP}$ *every boy*$]_{SG}]\!]([\![[$*is in the kitchen*$]_{SG}]\!])$
$= \lambda P \forall x[B(x) \rightarrow P(x)](\lambda x.SSG(x)[K(x)])$
$= \forall x[B(x) \rightarrow [K(x)]]$, as $\forall x[B(x) \rightarrow SSG(x)]$, as AT(B).

Notice that the singularity requirement of the predicate is satisfied, as every x in the predicate B satisfies SSG(x), as B is atomic.

Now, we can lift Boolean conjunction $\wedge$ from truth values to propositions and also to quantifiers in a generalized way (cf. Partee & Rooth 1983, Keenan & Faltz 1985). First, $\wedge$ is defined for truth values; we have $t \wedge t' = 1$ iff $t=1$ and $t'=1$, else 0. Hence, truth values are conjoinable. Second, for meanings f, g of the same type that are functions into conjoinable meanings, we generalize $\wedge$ to $f \wedge g = \lambda X[f(X) \wedge g(X)]$, where X is a variable of the type of arguments of f and g. If we allow for *and* to be also interpreted as Boolean conjunction, which we need for the coordination of clauses and predicates anyway, we can derive the Q&Q as follows (we use the predicate variable P′ here instead of X):

(21) $[\![[_{DP}$ [$_{DP}$ *every boy*] *and* [$_{DP}$ *every girl*]]]$\!]$
$= [\![[_{DP}$ *every boy*$]]\!] \wedge [\![[_{DP}$ *every girl*$]]\!]$
$= \lambda P \forall x[B(x) \rightarrow P(x)] \wedge \lambda P \forall x[G(x) \rightarrow P(x)]$
$= \lambda P' [\lambda P \forall x[B(x) \rightarrow P(x)](P') \wedge \lambda P \forall x[G(x) \rightarrow P(x)](P')]$
$= \lambda P' [\forall x[B(x) \rightarrow P'(x)] \wedge \forall x[G(x) \rightarrow P'(x)]]$

Applying (21) to the verbal predicate results in the following representation, using the singular form of the predicate:

(22) ⟦[[$_{DP}$ [$_{DP}$ *every boy*] *and* [$_{DP}$ *every girl*]][*is in the kitchen*]$_{SG}$]⟧
⟦[$_{DP}$ [$_{DP}$ *every boy*] *and* [$_{DP}$ *every girl*]]⟧(⟦[*is in the kitchen*]$_{SG}$⟧)
= λP′[∀x[B(x) → P′(x)] ∧ ∀x[G(x) → P′(x)]](λx.SSG(x)[K(x)])
= [∀x[B(x) → λx.SSG(x)[K(x)](x)] ∧ ∀x[G(x) → λx.SSG(x)[K(x)](x)],
as all x such that B(x) and all x such that G(x) satisfy SSG(x).

Hence, singular agreement is justified for semantic reasons, and this explains why singular predicates are generally judged quite good with conjunctions of two quantifiers. Notice that we had to assume a systematic ambiguity of *and* here between sum formation ⊔ and Boolean conjunction ∧. The symbol "&" that we used for conjunction in general can be spelled out in distinct ways, as ⊔ or as ∧.

5.5 Conjunction of referential and quantified DP: D&Q

Phrases like *the boy and every girl* involve a type mismatch: *the boy* is entity-referring, whereas *every girl* is a quantifier, a second-order predicate. These two meanings do not match, and cannot be coordinated in a straightforward way. The general strategy for the interpretation is to assume that the referring DP *the boy* is lifted to a quantifier (cf. Partee & Rooth 1983, Partee 1987). In the case at hand, *the boy* is lifted to the set of properties that the denotation of *the boy* has, cf. (23). The LIFT operation leads to a configuration in which referring DPs and quantified DPs can be conjoined, cf. (24).

(23) LIFT(x) = λP[P(x)]

(24) ⟦[[$_{DP}$ [$_{DP}$ *the boy*] *and* [$_{DP}$ *every girl*]][*is in the kitchen*]$_{SG}$]⟧
= ⟦[$_{DP}$ [$_{DP}$ *the boy*] *and* [$_{DP}$ *every girl*]]⟧(⟦[*is in the kitchen*]$_{SG}$⟧)
= [LIFT(⟦[$_{DP}$ *the boy*]⟧) ∧ ⟦[$_{DP}$ *every girl*]⟧](⟦[*is in the kitchen*]$_{SG}$⟧)
= [λP[P(ιB)] ∧ λP∀x[G(x) → P(x)](λx.SSG(x)[K(x)])
= λP[P(ιB) ∧ ∀x[G(x) → P(x)](λx.SSG(x)[K(x)])
= λx.SSG(x)[K(x)])(ιB) ∧ ∀x[G(x) → λx.SSG(x)[K(x)](x)]
= K(ιB) ∧ ∀x[G(x) → K(x)],
as SSG(ιB) is satisfied and every x such that G(x) satisfies SSG(x).

The same derivation also holds for the other order, Q&D, *every boy and the girl*. We will turn to the fact that this rather shows plural agreement in section 5.10.

5.6 Boolean conjunction and disjunction of DPs: D∧D and D∨D

We have seen that cases like *sowohl der Junge als auch das Mädchen*, or *both the boy and the girl*, allow singular agreement more easily. We can explain this by assuming that such constructions can only be interpreted as Boolean conjunction, and not as sum formation. We may interpret sentences with such subjects as evidence for syntactic deletion, or as a forced interpretation by Boolean conjunction ∧ that enforces type-lifting as in (25):

(25) ⟦[[*both* [DP *the boy*] *and* [DP *the girl*]] [*is in the kitchen*]SG]]⟧
= [LIFT(⟦[DP *the boy*]⟧) ∧ LIFT(⟦[DP *the girl*]⟧)](⟦[*is in the kitchen*]SG⟧)
= λP[P(ιB) ∧ P(ιG)](λx.SSG(x)[K(x)])
= K(ιB) ∧ K(ιG), as SSG(ιB) and SSG(ιG) are satisfied

Singular agreement with disjunctive DPs can be explained similarly. The only way to interpret disjunction ∨ is as a Boolean operation, which then leads to the following interpretation, with enforced type lifting:

(26) ⟦[[[DP *the boy*] *or* [DP *the girl*]] [*is in the kitchen*]SG]]⟧
= [LIFT(⟦[DP *the boy*]⟧) ∨ LIFT(⟦[DP *the girl*]⟧)](⟦[*is in the kitchen*]SG⟧)
= λP[P(ιB) ∨ P(ιG)](λx.SSG(x)[K(x)])
= K(ιB) ∨ K(ιG), as SSG(ιB) and SSG(ιG) are satisfied

In conclusion, we have shown why singular agreement is possible in cases like Q&Q, D&Q, D∧D and D∨D, in contrast to D&D, which only allows for plural agreement. However, our experimental results showed that in all these cases, plural agreement is possible as well, and even is judged better, to which we now turn.

5.7 Syntactic agreement

Plural agreement can be explained by a competing syntactic rule of number agreement. For this, we assume a plural assignment rule for coordinated DPs:

(27) [[DP α]x-NUM C [DP β]x-NUM]PL

This states that a coordination of two DPs results in a plural DP, regardless which number feature the subconstituents have. Using (27) for the various cases discussed above as an option, we find that plural number is justified for all these cases as well, as by the following derivation, illustrated here for Q&Q. In order for this to work, the number feature PL is a purely formal feature that is not interpreted.

(28) [[DP [DP *every boy*]SG *and* [DP *every girl*]SG]**PL** [*are in the kitchen*]**PL**]

Indeed, plural agreement is rated better in all the cases we have considered. This may be due to the fact that the syntactic agreement rule does not care about the semantic interpretation, and hence can be applied in an automatic and fast way.

If we assume that the syntactic rule (27) is applied whenever possible, and enforces plural agreement of the predicate as in (28), we would predict that singular agreement is categorically ruled out. Hence the syntactic rule (27) applies only optionally. We will return to the nature of the syntactic agreement rule in Section 6.

5.8 Conjunction of referential DPs D&D: Why no singular agreement?

We have derived in section 5.3 that the conjunction of two referential DPs triggers plural semantic agreement, as *and* is interpreted as sum operation, ⊔. It also triggers plural syntactic agreement following (27), and this predicts the experimental result, that singular agreement is considered bad. However, notice that there is a way to derive singular agreement, as *and* could be interpreted as Boolean conjunction as well, triggering type lifting as in the case of *both the boy and the girl* in section 5.6.

(29) ⟦[[[$_{DP}$ *the boy*] *and* [$_{DP}$ *the girl*]] [*is in the kitchen*]$_{SG}$]]⟧
= [LIFT(⟦[$_{DP}$ *the boy*]⟧) ∧ LIFT(⟦[$_{DP}$ *the girl*]⟧)](⟦[*is in the kitchen*]$_{SG}$⟧)

The type lifting and choice of ∧ as interpretation of *and* can be seen as triggered by the singular form of the predicate. As we have argued, the syntactic agreement rule should be considered as optional. The prediction appears to be that singular agreement for D&D should be better than it actually is.

We can explain the avoidance of singular agreement by optimality-theoretic reasons when we assume that (i) we look for ways that a syntactic string can be parsed, which includes selecting possible interpretations of words and type-lifting operations, and (ii) type-lifting operations are penalized and should be avoided if possible. Then the derivation (29) is ruled out, as the string can be interpreted in a simpler way, as (17) shows. This assumes that the plural form of the predicate, which is morphologically more complex than the singular form, does not weigh in as heavily as the LIFT operation. In the cases where singular agreement is possible, as in Q&Q, D&Q, D∨D and also D∧D, where the conjunctor *both… and…* forces Boolean conjunction, there is either no other derivation, as in in the Q&Q case, or the LIFT operation is enforced to enable the only interpretation that is possible.[8]

[8] As a historical aside, we would like to point out a curious asymmetry in the treatment of conjunction and disjunction in Montague 1973. Montague introduces coordination as a syncategorematical operation – that is, *and* and *or* are not interpreted directly but by two syntactic rules, F_8 and F_9 respectively, with corresponding semantic interpretation rules. However, DPs (the category of terms, T) can only be conjoined by the rule for disjunction, F_9 (rule S_{13}), in contrast to sentences and verb phrases, which also allow for conjunction. This is clearly because Montague's

Another way of explaining the impression that singular agreement is ungrammatical in the D&D case is that it has both a semantic and a syntactic derivation that results in plural agreement. In contrast, singular agreement would result in a tension between the outcome of syntactic agreement and semantic agreement. This tension can be circumvented by plural agreement, and hence singular agreement is avoided.

Notice that this line of reasoning predicts that whenever there is competition between two ways of processing a structure (which includes syntactic parsing and semantic interpretation), there should be evidence for degradation in the evaluation of either way of processing. The rating of the plural agreement forms in Q&Q, D∨D, D&Q and Q&D is indeed slightly reduced in comparison with the D&D case, but this is not statistically significant with the methods and number of items used in our experiment (the result of D∧D is the same as for D&D). Hence, further experiments would have to decide whether the competing ways of processing lead to acceptable results individually reduce the rating of a syntactic form.

5.9 Forced plural agreement with Q&Q with reciprocal predicates

Our experiment showed that Q&Q allows for plural agreement, and we could motivate this, as it is licensed by the syntactic agreement rule However, plural agreement is obligatory with reciprocal predicates. Such cases have been discussed in the semantic literature as "branching quantifiers" (Barwise 1976, Westerståhl 1987). We see that reciprocal predicates, and in general collective predicates like *be connected*, enforce plural agreement (the judgment is our own rating):

(30) *Every circle and every dot *is / are connected (with each other).*

The interpretation of sentences like (30) cannot be based on a Boolean conjunction of two quantifiers, as this does not provide for the sum individuals required for the reciprocal predicate. The interpretation must rather be based on a generalized sum operation. Such generalizations of the sum operation on quantifiers have been proposed by Hoeksema (1983, 1988) and Krifka (1990).

The generalization proceeds similar to the case of Boolean conjunction ∧ in section 5.4. First, we note that entities can be joined by the sum operation ⊔. Second, for any predicates f, g of the same type that are functions into meanings that can be conjoined by ⊔, we have $f \sqcup g = \lambda x \exists y \exists z[y \sqcup z = x \wedge f(y) \wedge g(z)]$. For example, *blue and green* is interpreted as $B \sqcup G$, i.e. $\lambda x \exists y \exists z[y \sqcup z = x \wedge B(y) \wedge G(z)]$,

fragment only provided for singular forms. Referential DPs were interpreted as quantifiers, e.g. *John* as j^*, an abbreviation for $\lambda P[^\vee P(^\wedge j)]$, which corresponds to extensional $\lambda P[P(j)]$, or $LIFT(j)$. Montague could allow for disjunctions of T in his fragment because the singular form is acceptable, but not for conjunctions, as they would have required a plural form, at least for cases like *John and Mary*.

applying to objects that are partly blue and partly green. We assume a third rule, here stated with reduced generality for simplicity, that applies to meanings f, g that have arguments which are conjoinable by the sum operation, ⊔, and result in meanings that can be conjoined by Boolean ∧, namely f⊔g = λX∃Y∃Z[Y⊔Z ⊆ X ∧ f(Y) ⊔ g(Z)] (where Y⊔Z ⊆ X is shorthand for ∀W[[Y⊔Z](W) → X(W)]). Applying the conjunction ⊔ to two quantified DPs we get the following result:

(31) ⟦[[*every circle*] *and* [*every dot*]]⟧
= λP∃P′∃P″[P′⊔P″ ⊆ P ∧ ⟦[*every circle*]⟧(P′) ∧ ⟦[*every dot*]⟧(P″)]
= λP∃P′∃P″[λx∃y∃z[y⊔z = x ∧ P′(y) ∧ P″(z)] ⊆ P
∧ ∀x[C(x) → P′(x)] ∧ ∀x[D(x) → P″(x)]]

Assuming a strong interpretation of the reciprocal, where *be connected* (*with each other*), CON, holds for a sum individual x if and only if it holds for every non-overlapping parts y, z of x that y is connected with z (and vice versa), we then get the following interpretation for (30):

(32) ⟦[[[*every circle*] *and* [*every dot*]][*are connected*]$_{PL}$]⟧
= ⟦[[*every circle*] *and* [*every dot*]]⟧(⟦[*are connected*]$_{PL}$⟧)
= ∃P′∃P″[λx∃y∃z[y⊔z = x ∧ P′(y) ∧ P″(z)] ⊆ λx.¬SSG(x) CON(x)
∧ ∀x[C(x) → P′(x)] ∧ ∀x[D(x) → P″(x)]]

This states that we can form a predicate λx[…] such that x falls under CON, where x can be divided into a y and a z, and a predicate P′ applies to y, and a predicate P″ applies to z. Furthermore, it is stated that all circles have the property P′, and all dots have the property P″. This is possible if and only if every circle is connected to a star, and vice versa. As the arguments of λx[…] are all sum individuals, the presupposition of plural predicates, ¬SSG, applies, and singular predicates are ruled out. For this reason, only the plural form of the predicate is acceptable.

The interpretation of *and* by a generalized sum operation would allow to derive a meaning of sentences like *every circle and every dot are red* by way of the semantic agreement rule, in additional to the derivation by the syntactic agreement rule. However, one would expect that the interpretation of *and* by a generalized sum operation is fairly complex, and is imposed only when enforced by a collective or reciprocal interpretation.

5.10 The case of Q&D and closest conjunct agreement

Our experimental results in section 4 have revealed a potential asymmetry in the agreement patterns of conjunctions of mixed quantificational and referential DPs: Singular agreement was rated worse, and plural agreement was rated better, for

Q&D than for D&Q. What could account for this difference in the order of referring DP and quantified DP?

We propose that this is a consequence of the well-known effect of closest conjunct agreement (cf. Nevins & Weisser 2019 for a recent overview). In languages with gender agreement of the predicate, a coordinated subject [DP_1 c DP_2] often results in an agreement with the DP that is syntactically closest to the predicate, e.g. DP_2 in a subject-predicate structure. This appears to be a purely syntactic effect of sentence processing. But this cannot account for our observations in a direct way, as we have considered only cases with singular DPs, and so closest conjunct agreement in a subject-predicate clause should always lead to singular agreement.

However, closest conjunct agreement may play an indirect role. Consider the case of [Q&D], with D as the closest conjunct to the predicate. Masking the other conjunct, we have the structure […&D]. This is formally identical to the structure [D&D], which always triggers plural agreement. We can assume that coordinated subjects of the form [D&D] are much more frequent than [Q&D], which is a reason that their agreement pattern becomes prominent for […&D] structures in general, including [Q&D]. Hence, even though D is singular, the reason for closest conjunct agreement contributes to the strong preference for plural agreement in this case.

In contrast, [D&Q] is an instance of the pattern […&Q]. This pattern also instantiates [Q&Q], which arguably is more frequent than [D&Q], and allows for semantic singular agreement. Consequently, we expect that singular agreement for [D&Q] is rated similar as for [Q&Q]. This corresponds to our experimental finding, except that singular agreement with [D&Q] examples was generally rated lower than [Q&Q] examples. The reason for this might be that the [D&Q] examples require a LIFT operation that is not necessary for the [Q&Q] examples.

6 Semantic agreement and the development of syntactic agreement

We started with reviewing some of the evidence that number agreement of predicates is to some extent governed by semantic interpretation, and we have contributed new evidence for that by looking at the agreement patterns of coordinated quantified DPs and DP disjunctions, which allow for singular agreement.[9] We have also called attention to the fact that the syntactic agreement rule that assigns plural to conjoined DPs is odd for theoretic reasons, if the conjuncts are singular.

[9] Other cases of semantic agreement in coordination concern agreement of two singular DPs with dual in languages like Slovenian (Himmelreich & Hartmann 2023) and the situation in Biak (Austronesian, Irian Jaya), where a conjunction of two paucal DPs leads to either paucal or plural agreement with the predicate, depending on the overall number of entities referenced to (Harbour 2020).

We would like to propose that the syntactic agreement rule is motivated by the semantic agreement rule. The idea is that the typical DP coordination is conjunction of two referential DPs, and this results in semantic plural agreement, as we have seen. These coordinations are frequent exemplars encountered in ordinary language use, which then become the model for agreement in general. Hence, syntactic agreement can be seen as a generalization, or shortcut, of the most frequent case of DP agreement. Dammel (2015) provides diachronic evidence for this development in German,[10] and Lorimor et al. (2018) adduce experimental evidence.

One essential premise of this argument is that conjunction of referential DPs is indeed the most frequent type of conjunction; this would have to be verified by corpus analysis. The initial evidence is promising; for example, a Google ngram search resulted in the following frequencies: "the man and the woman" (0.000136), "the man or the woman" (0.0000023), "every man and every woman" (0.0000012). That is, the D&D construction is 6 times as frequent as the DVD construction, and 11 times as frequent as the Q&Q construction.

The generalization of semantic agreement to a syntactic agreement rule does not mean that syntactic agreement is the only one that determines agreement. Our data showed that it is the strongest factor for plural agreement, at least for German, but that semantic agreement is still operative.

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[10] In a similar way, Thorvaldsdóttir (2019) showed that mixed-gender DP conjunctions in Icelandic are resolved as neuter agreement, and this is generalized to inanimate same-gender DP conjunctions.

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