Empirical investigations on quantifier scope ambiguities in German[*]

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Abstract. The paper presents the results of a novel experimental study on inverse scope readings in German, which are considered to be possible only under highly constrained conditions in prior literature (Frey 1993; Pafel, 2005; Bobaljik & Wurmbrand, 2012). We show that inverse scope readings are in fact possible in canonical main clauses with an ∃-subject QP preceding and c-commanding an ∀-object QP under verum focus, with the potential of object-scrambling over the subject. The existing literature on quantifier scope in German is unanimous in claiming that inverse scope is impossible in this configuration. Our findings are line with previous experiments on German that found inverse readings to be available in other syntactic configurations (e.g. Bott & Radó, 2007; Radó & Bott 2011; Bott & Schlotterbeck, 2015). Moreover, the availability of inverse readings is boosted when the context biases towards them, a finding which is compatible with previous evidence suggesting that context plays an important role in scope ambiguity resolution (Kurtzman & MacDonald, 1993; Saba & Corriveau, 2001; Villalta, 2003; Reinhart, 2006). Our results also suggest that inverse readings are not banned from relative clauses, a result that is incompatible with the assumptions that relative clauses are islands, and that inverse scope interpretations are obtained via the covert movement operation QR in syntax. Finally, we show that scope interpretation strategies differ drastically between speakers of the same language, in line with introspective judgments.

Keywords: quantifiers, scope, ambiguity, experiment, German, Quantifier Raising, relative clauses, islands, world knowledge.

1. Introduction

English sentences containing more than one quantificational expression give rise to quantifier scope ambiguities. An example with two argument QPs is given in (1).

(1)   A drone surveilled every building.

This sentence contains an existential subject-QP *a drone* and a universal object-QP *every building*. Under the surface reading (SR), on which the ∃-subject QP takes scope over the structurally lower ∀-object QP, the ∃-QP takes wide scope, giving rise to the interpretation that there is exactly one drone that surveilled all the buildings. Under the inverse reading (IR), it is the ∀-object QP taking scope over the ∃-subject QP, giving rise to the interpretation that for every building there is a drone such that this drone surveils it.
    May (1977, 1985) proposes a syntactic derivation of inverse scope readings through quantifier raising (QR) at the representational level of Logical Form (LF), effectively reducing

scope ambiguities to structural ambiguities. Quantifiers covertly rise out of vP at LF for reasons of interpretability. With sentences containing two QPs, the resulting c-command relationship between the two QPs at LF determines the readings obtained. The two readings of (1) are represented in a simplified manner in (2):

(2)   SR: [[∃ a drone]₁ [[∀ every building]₂ [t₁ surveilled t₂]]]   ∃>∀
       IR: [[∀ every building]₂ [[∃ a drone]₁ [t₁ surveilled t₂]]]   ∀>∃

Importantly, QR is typically taken to obey the same constraints as overt A'-movement (Huang 1995). This theory has been adopted and modified by many subsequent authors (e.g. Heim & Kratzer, 1998; Chierchia & McConnell-Ginet, 2000; Fox, 2000 i.a.).

    Even though sentences like (1) are potentially ambiguous, the readings are often not available to the same extent, and sometimes one reading is in fact completely ruled out. In general, inverse readings have been observed to be less available than surface readings across languages. They are grammatically dispreferred (e.g. Reinhart, 2006) and induce higher processing costs (e.g. Kurtzman & MacDonald, 1993; Anderson, 2004). Over the years, both theoretical as well as experimental work has accumulated a large number of possible factors with an impact on the availability of inverse readings, depending on the grammar of a given language: prosody (Frey, 1993; Büring, 1997; Krifka, 1998; Pafel, 2005), linear order (Reinhart, 1983; Frey, 1993; Pafel, 2005), word order flexibility (Krifka, 1998; Bobaljik & Wurmbrand, 2012), syntactic construction (Sauerland & Bott, 2002), syntactic constraints (Bobaljik & Wurmbrand, 2012), grammatical role (Ioup, 1975; VanLehn, 1978; Pafel, 2005), semantic role (Frey, 1993; Pafel, 2005), features of the determiners (Ioup, 1975; VanLehn, 1978; Ruys, 1993; Beghelli & Stowell, 1997; Szabolcsi, 1997; Pafel, 2005), information structure (Partee, 1991; Frey, 1993; Suranyi & Turi, 2017), discourse anaphoricity (Pafel, 2005), context/world knowledge (Kurtzman & MacDonald, 1993; Saba & Corriveau, 2001; Villalta, 2003; Anderson 2004), as well as economy principles (Fox, 1995).

    Specifically for German, several authors have claimed that inverse readings are hardly ever available. To the extent that they are, they only occur in a very restricted set of contexts. Frey (1993), for instance, proposed the Scope Principle, which says that a QP A has scope over a QP B, iff the head of the chain A c-commands the base of the chain B. In effect, a given QP₁ can only take scope over QP₂, if QP₁ c-commands QP₂ directly in overt syntax, or else if QP₁ c-commands the base position of QP₂ after overt movement. It follows that inverse readings in German are only possible in non-canonical word orders after overt movement. Inverse readings are thus not obtained via QR but via reconstruction at LF. An example is given in (3) vs. (4):

(3)   Tatsächlich HAT mindestens eine Drohne fast   jeden Hügel überflogen.
       Indeed   has   at least   a   drone almost every hill   overflown
       Indeed, at least one drone_{sbj} has overflown almost every hill_{obj}.   ∃∀, *∀∃
(4)   Tatsächlich HAT [mindestens einen Hügel]₁ fast jede Drohne t₁ überflogen.
       Indeed, [at least one hill_{obj}]₁ has overflown almost every drone_{sbj} t₁.   ∃∀, ∀∃

According to Frey (1993), the sentence in (3) should be unambiguous and only have the surface ∃∀-reading. Example (4) with overt object scrambling, by contrast, can have both readings since the ∀-subject QP c-commands the base position of the ∃-object QP. This analysis is subject to two constraints limiting its range of applicability. First, Frey acknowledges that

prosody can have an impact on interpretation and that therefore, the predictions only hold for sentences with verum focus. Second, Frey does not consider many quantificational expressions as *bona fide* quantifiers, thereby restricting the scope principle to only hold for a subset of quantificational expressions. This excludes default quantificational expressions such as indefinite *ein* 'a/some' or *jeder* 'every', but includes complex expressions such as *mindestens ein* 'at least one' or *fast jeder* 'almost every'. According to Frey, the unmodified existential indefinite *ein* 'one' can also receive a directly referential interpretation, on which it would be scope free, and universals such as *jeder* 'every' can also receive a referential interpretation under a collective construal. Crucially, though, the same argument can be made for expressions that, according to Frey, are actual quantifiers. For instance, *mindestens ein* 'at least one' can also receive a referential interpretation via reconstruction of its witness set (Szabolcsi 1997), and the same would appear to hold for *fast jeder 'almost every'*, which likewise allows for anaphoric reference with the 3rd plural pronoun *sie* 'they'. For this reason, and because they impose fewer processing constraints on experimental participants, we decided to carry out the experiment on the simple quantificational expressions *ein* and *jeder*; see also Footnote 1.

The multi-factorial account of Pafel (2005) also considers non-syntactic factors to have an impact on quantifier scope interpretation in German. Following Ioup (1975), Pafel argues that many different weighted factors interact with each other in a cumulative manner, thereby resulting in different scope preferences. In particular, each relevant factor has a fixed value, which is assigned to the QP in the sentence that this factor applies to. The single values are then multiplied by five, and the results summed up. For sentences with two QPs, the resulting numerical values for the individual QPs are compared. If the difference is greater than or equal to five, the sentence will be unambiguous with wide scope to the QP with the higher value. If the difference is smaller than five, the sentence will ambiguous, as shown in (5).

(5)   *Einen Hügel* überflog *jede Drohne.*
     A hill$_{obj}$overflew every drone$_{sbj}$.
     ∃:   linear order: 1.5x5 = 7.5
     ∀:   grammatical function: 1x5 + distributivity: 1x5 = 10

(5) is ambiguous because the difference of the resulting values (7.5 vs. 10) is smaller than five. The ∃-QP receives a value for the factor *linear order*, because it linearly precedes the ∀-QP. The ∀-QP in turn receives a value for *grammatical function*, because it is the subject, and subjects are more prone to take wide scope. The ∀-QP also receives a value for *distributivity*, because it has the inherent feature of being distributive, which also increases the likelihood for wide scope (Ioup 1975). The advantage of Pafel's approach is that it can account for the influence of many different factors. However, it is more descriptive than explanatory in nature, and the values were only assigned on the basis of introspective judgments.

Finally, Bobaljik & Wurmbrand (2012) provide a principled account of quantifier scope preferences across various languages. They reject the notion of global scope rigidity for individual languages, such as German, and assume that the operation of QR is universally available across languages. In addition, they suggest that a soft economy constraint called Scope Transparency (ScoT) is at play. This constraint says that if A precedes B at LF, then A also precedes B at PF. This constraint is violable, for instance if it is outperformed by a higher-ranked constraint blocking overt movement. This way, Bobaljik & Wurmbrand (2012) arrive at a notion of local scope rigidity. They predict that ScoT strongly restricts the availability of

inverse readings in German with its relatively free word order. This is so because, in principle, in many cases overt movement of the structurally lower QP would be possible so that there is no reason for violating ScoT by having a mismatch between LF and PF. In a rigid word order language such as English, however, ScoT is frequently violated as overt movement is blocked, thereby allowing for inverse scope readings. However, inverse readings are possible even in German, namely in configurations in which overt movement is blocked by general and inviolable constraints on movement. This is shown in (6).

(6)   *Context:* Two friends are talking about last night, when one of them visited Peter, who is crazy about jazz. On that occasion, Peter played a record by Miles Davis, a record by John Coltrane, and a record by Fred Frith.

    a.   Peter hat [eine Platte [jedes Musikers]]   aufgelegt. $\exists\forall, \forall\exists$
              Peter has a   record   every musician.$_{GEN}$ played

    a'.   *Peter hat [jedes Musikers]$_1$ [eine Platte t$_1$ aufgelegt]
              Peter has every musician.$_{GEN}$ a   record   played

    b.   Peter hat [eine Platte [von jedem Musiker]] aufgelegt. $\exists\forall, *\forall\exists$
              Peter has a   record by every musician played.

    b'.   Peter hat [von jedem Musiker]$_1$ [eine Platte t$_1$] aufgelegt.
              Peter has by every musician   a   record   played.
              'Peter has played a record by every musician.'
              (adapted from Bobaljik & Wurmbrand 2012: 381f.; exs.12a & 13a)

In nested DPs such as in (6a), the lower $\forall$-QP each *musician$_{GEN}$* is the genitive complement of the higher existential *a record*, and cannot move overtly, as evidenced by the ungrammaticality of (6a'). (6a) is therefore predicted to be ambiguous. In (6b), however, the second QP *by every musician* is a PP-adjunct and can overtly move, as seen by the grammaticality of (6b'). (6b) is therefore predicted to only allow for the surface reading.

    A number of experimental studies on quantifier scope ambiguities in German are found in the literature, some explicitly testing for the adequacy of the theoretical accounts above (Bott & Radó, 2007; Bott & Radó, 2009; Radó & Bott, 2011; Radó & Bott, 2018; Bott & Schlotterbeck, 2012; Bott & Schlotterbeck, 2015). These studies show (i.) that $\forall$-QPs headed by the distributive universal *jeder* (= 'every') take wide scope more often than those featuring the collective universal *alle* (= 'all'), (ii.) that linear order plays an important role in that the surface reading is typically the preferred reading, and (iii.) that d-linked QPs (e.g. partitives) take wide scope more often than non-d-linked QPs. The experimental studies also provided some evidence that inverse readings are accepted in many different contexts even though they are generally dispreferred. In fact, the inverse reading even seems to be the preferred interpretation in inverse linking constructions, such as *[Ein Apfel [in jedem Korb]] ist faul* 'An apple in every basket is rotten' (Bott & Radó, 2009; 2011). The authors conclude that the experimental results are not fully compatible with any of the theories on quantifier scope in German, but mostly in favour of multi-factorial accounts à la Pafel (2005). Our experiment adds to the available empirical evidence on quantifier scope in German by focussing on a syntactic configuration that has not been investigated in previous experimental work, except for an informal pen-and-paper study in Zimmermann (1997): sentences with $\exists$-subject QP and $\forall$-object QP in canonical word order (= no overt movement) under verum focus to control for the effects of accent. We present evidence that inverse scope readings are available in this

syntactic configuration, for which none of the above theories on German quantifier scope has deemed possible. In addition, we also look at the role of syntactic constraints on islandhood, as well as at the impact of context/world knowledge on the interpretation of potentially scope ambiguous sentences.

2. Experiment: An offline study on the availability of inverse scope in German

In this experiment we investigated the general availability of inverse scope readings between ∃-subject and ∀-object QPs (in this order) by means of an offline behavioural task. We judged for the (un)availability of a given scope reading by presenting participants with critical target sentences in contexts and by eliciting *yes/no*-responses on a content question that would allow to assess the availability (yes-answer) or unavailability (no-answer) of this scope reading. In particular, we were interested in the following three research questions:

Q1: *Is inverse scope between ∃-subject QPs and ∀-object QPs available in German?* The three analyses of quantifier scope ambiguities in German above differ regarding the configurations for which they predict inverse scope readings to be available. However, they all agree that inverse readings are unavailable in the critical syntactic configuration in (7a), illustrated again in (7b), at least under verum focus.

(7) a.   … V$_{FIN}$ **∃-SUBJ ∀-OBJ**   V
     b.   … und tatsächlich hat dann   [´**ne Drohne**] [**jedes Gebäude**]   überwacht.
                 and indeed   has   then   a drone   every building   surveilled
                 … and then, indeed, a drone surveilled every building.

Q2: *Does context plausibility have an impact on the availability of inverse scope?* While there is some work on English quantifier scope suggesting that context or world knowledge may play a crucial role in resolving scope ambiguities (Reinhart 2006), this has not been subject to systematic experimental research in German or other languages, which tends to focus on structural, semantic, and prosodic factors.

Q3: *Does embedding into a syntactic island render the inverse reading impossible?* Inverse readings can be syntactically derived by the covert movement operation of Quantifier Raising. Whereas neither Pafel's (2005) nor Frey's (1993) theory is based on QR, Bobaljik & Wurmbrand's (2012) is. Since QR is claimed to be blocked by inviolable syntactic constraints on overt movement, we would expect inverse scope out of relative clause islands to be systematically unavailable. We therefore also test for inverse scope out of relative clause islands.

2.1. Experimental Design

Target Sentences: We employed a 2x3 Latin Square design with the factors (i) *context plausibility* (2 levels) and (ii) *island embedding* (3 levels). The former was a between-item manipulation with the levels *neutral,* in which both surface and inverse reading were equally plausible, and *IR-biased*, in which only the inverse reading was compatible with common knowledge. An example for a scenario with an IR-bias is shown in (9), in which it is extremely

unlikely that a single tree would block every entrance to the city. A pre-test in which participants had to rate the plausibility of the two scenarios allowed us to assign half of the items to *neutral* and half of the items to *IR-biased*. This factor was included to test for Q2 regarding the influence of world knowledge and plausibility considerations on scope interpretation. The second factor, *island embedding*, was a between-item manipulation with the levels *0-emb*, in which the target sentence remained unembedded; *1-emb*, in which the ∀-object QP was embedded in a relative clause island; and *2-emb,* in which the ∀-object QP occurred doubly embedded. We included this factor to test for Q3 regarding the availability of inverse scope from syntactic islands. An example for the neutral condition is given in (8) and for the IR-biased condition in (9). The different target sentences where followed by either of two content questions Q-SR or Q-IR, shown in both (8') and (9'), which tested for the availability of surface and inverse scope reading, respectively.

(8)   *neutral*
        Der Agrarexperte hatte empfohlen, dass die Felder durch breite Kanäle bewässert werden sollten, …
        The agriculture expert had recommended that the fields be irrigated by wide canals, ...

        0-emb … und tatsächlich hat dann 'n breiter Kanal jedes Feld bewässert.
               … and then, indeed, a wide canal irrigated every field.
        1-emb … und tatsächlich hat sich dort dann 'n breiter Kanal befunden, der jedes Feld bewässert hat.
               … and then, indeed there was a wide canal that irrigated every field.
        2-emb … und tatsächlich war dort dann 'n breiter Kanal, der so angelegt war, dass er jedes Feld bewässert hat.
               … and then, indeed, there was a wide canal, which was constructed in such a way that it irrigated every field.

(8')   Kann man diesen Satz so verstehen, dass es hier insgesamt…
        Can this sentence be understood to mean that overall ...

        Q-SR   … nur einen einzigen Kanal gab, der die Felder bewässert hat?   Yes/No
               … there was only a single canal that irrigated the fields?
        Q-IR   … mehr als einen Kanal gab, der die Felder bewässert hat?   Yes/No
               … there was more than one canal that irrigated the fields?

(9)   *IR-biased*
        Die Polizei hatte vor dem Sturm davor gewarnt, dass die Zufahrten in die Innenstadt durch umgestürzte Bäume blockiert werden könnten, …
        The police warned before the storm that the entrances to the city centre could be blocked by fallen trees ...

        0-emb … und tatsächlich hat dann 'n umgestürzter Baum jede Zufahrt blockiert.
               … and then, indeed, a fallen tree blocked every entrance.
        1-emb … und tatsächlich hat dort dann 'n umgestürzter Baum gelegen, der jede Zufahrt blockiert hat.
               … and then, indeed, there was a fallen tree that blocked every entrance.

> 2-emb … und tatsächlich war dort dann 'n umgestürzter Baum, der so gelegen hat, dass er jede Zufahrt blockiert hat.
> *… and then, indeed, there was a fallen tree that was positioned in such a way that it blocked every entrance.*

(9') Kann man diesen Satz so verstehen, dass es hier insgesamt …
Can this sentence be understood to mean that overall …

> Q-SR … nur einen einzigen umgestürzten Baum gab, der die Zufahrten blockiert hat?
> *… there was only a single tree that blocked the entrances?* Yes/No
> Q-IR … mehr als einen umgestürzten Baum gab, der die Zufahrten blockiert hat?
> *… there was more than one tree that blocked the entrances?* Yes/No

As can be seen in (8) and (9), all target items came with canonical word order, that is with the subject QP preceding and c-commanding the object QP at surface structure. The subject was always an existential QP with the abbreviated form *'n(e)* of the indefinite article *ein(e)* (= 'a/some'), whereas the object was always a universal QP headed by the distributive universal *jede(r)* (= 'every'). Using the abbreviated form instead of the full form of the indefinite was a way of controlling for intonation in a written experiment. The abbreviated form cannot carry stress, thereby avoiding potential prosodic confounds, which could boost either (i.) a specific (= wide scope, Krifka 1998, Ebert 2009) interpretation of the indefinite, namely if participants give it main stress, or (ii.) an inverse scope interpretation, namely if participants read the sentence with a rise-fall contour (Krifka, 1998). Moreover, as Frey's (1993) strict claim against inverse scope was restricted to verum-focus contexts, we included this factor into our design as well.[1] In order to justify the use of the somewhat colloquial form *'n(e),* we adapted all word forms in the experimental items to exhibit a more colloquial style. The preceding contexts always contained two DPs corresponding to the NP-complements of the existential and universal quantifier in the target sentence QPs. This was done in order to control for information structure by giving both QPs the information status *given*, resulting in de-accenting (Schwarzschild 1999). Moreover, the context sentences were in the passive voice, so that linear order and grammatical role of the relevant DPs was reversed. This was done to control for the topic-comment structure of the target sentences: For instance, the initial definite subject DP *die Felder* 'the fields' in the context clause in (8) plausibly constitutes the topic of the target sentence as well. This manipulation was introduced because Bobaljik & Wurmbrand (2012) allow for the possibility of inverse scope, i.e. a violation of ScoT, if overt movement is blocked by the information-structural constraint Topic > Focus. Given that the most plausible candidate for topic status in our target sentences is the ∀-object QP, we are confident that overt movement is not blocked by information structure. The DPs occurred in their number-neutral plural form

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[1] As discussed above, the claims in Frey (1993) are also restricted to what is considered *bona fide* quantifiers that do not allow for a referential type <e>-interpretation. However, using such quantifiers would require exposing participants to process more complex constructions like *Mindestens ein Baum hat fast jede Straße blockiert.* (= 'At least one tree blocked almost every road'), which in turn might induce another confound due to processing overload. Because of this, and since we are not convinced that modified quantifiers disallow referential interpretations, we omitted this aspect from our design. In addition, the use of the reduced weak indefinite form *´ne* significantly diminishes the possibility of a referential specific construal for the existential QP.

in the contexts (Corbett 2000, Chierchia 1998).[2] Each target sentence was followed by one out of two possible questions, Q-SR and Q-IR, respectively. Half of the items were followed by Q-SR and half of the items by Q-IR, in randomized order. Again, this kind of task allowed us to investigate to what extent inverse scope readings are available at all, in contrast to some kind of forced-choice task, that can only test which reading is preferred. Our linking hypothesis is that the inverse scope reading is available for a participant for a given item if the participant answers Q-IR in (8') or (9') with 'Yes', and that it is unavailable if Q-IR is answered with 'No'.

Filler/Control Items: In addition to the critical items, we also included five different types of filler/control items, which were all unambiguous in only allowing for either a *yes-* or a *no-* response to Q-SR and Q-IR. The three conditions in (10)–(12) should elicit 'yes'-responses to Q-SR, and the two conditions in (13)–(14) should elicit a 'yes'-response to Q-IR.

(10) *No universal QP: Q-SR ⇒ yes, Q-IR ⇒ no*
       Die Angestellten der Pistenwache ham wegen der Lawinengefahr angekündigt, 'ne Piste vorübergehend zu sperren, und tatsächlich ham **sie** dann auch **'ne Piste** gesperrt.[3]
       *The employees of the ski patrol announced that they would temporarily close a ski slope due to the danger of avalanches, and then, in fact, **they** did close **a ski slope.***

(11) *No universal, 2-emb: Q-SR ⇒ yes, Q-IR ⇒ no*
       Die Sekretärin hat vorgeschlagen, dass der verschwundene Brief unter Mappen versteckt sein könnte, und tatsächlich war dort dann 'ne Mappe, die so gelegen hat, dass sie **den Brief** bedeckt hat.
       *The secretary suggested that the missing letter might be hidden under folders, and then, in fact, there was a folder that was positioned in such a way that it covered **the letter.***

(12) *Referential: Q-SR ⇒ yes, Q-IR ⇒ no*
       Die Reisenden ham verlangt, dass 'ne Fahrt an die Ostsee angeboten wird, und tatsächlich hat dann **'ne Busfahrerin** jeden Reisenden zur Ostsee gefahren. Ich hab' aber **ihren Namen** vergessen.
       *The travelers demanded that a trip to the Baltic Sea be offered, and then, in fact, **a bus driver** drove every traveller to the Baltic Sea. But I forgot **her name**.*

(13) *Jeweils (= binominal each): Q-SR ⇒ no, Q-IR ⇒ yes*
       Die Mieter im Erdgeschoss ham gedroht, 'ne Beschwerde aufgrund des Schlagzeugs im ersten Stock einzureichen, und tatsächlich ham **sie** dann auch **jeweils 'ne Beschwerde** eingereicht.
       *The tenants on the ground floor threatened to file a complaint about the drums on the 1st floor, and then, in fact, **they each** filed **a complaint**.*

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[2] This decision may introduce another potential confound: when participants see a plural DP in the context, they may be biased to respond to the plural Q-IR with *Yes* and to Q-SR with *No*. However, it is impossible to avoid this problem. It is necessary to introduce the two DPs in the preceding context to control for information structure, but as soon as we do so we must decide for either the singular or the plural form, thereby inducing a bias in either direction. We therefore opted for the number-neutral (bare) plural form, which is less likely to induce a bias.
[3] As mentioned further above, the items were written in a more colloquial style to mask the use of the abbreviated indefinite, e.g. by writing *ham* for *haben* (= have) or *solln* for *sollen* (= shall/should).

(14) *Universal preceding existential: Q-SR $\Rightarrow$ no, Q-IR $\Rightarrow$ yes*[4]
Der Arzt hat angewiesen, dass die Krankenschwestern von Pflegern unterstützt werden solln, und tatsächlich hat dann jeder Pfleger 'ne Krankenschwester unterstützt.
The doctor ordered that the nurses should be supported by care-givers, and then, indeed, each caregiver supported a nurse.

Procedure: The experiment was conducted online with the free software OnExp. The experiment included in total 48 target items and 48 filler/controls, presented one after another in randomized order. Participants could choose to take a break in the middle of the experiment or whenever they felt tired. Participants were told that there were no right or wrong answers, and they were encouraged to answer the questions on the basis of their own intuition about the individual sentences. 70 students were recruited via the participant pool of University of Potsdam (SONA), and they could carry out the experiment for a monetary compensation of 8 EUR or for course credit. Three of the 70 participants were excluded from the analysis for answering less than 2/3 of the unambiguous control items correctly. The remaining 67 participants were within an age range of 17–58 and had a mean age of twenty-four years. 59 of them were female and 8 of them were male. All of them were native speakers of German.

2.2. Predictions

None of existing accounts of German quantifier scope predicts inverse scope readings to be available for the sentence structures investigated in the experiment. We now explain the theoretical reasoning behind the predictions of each account.

Frey (1993) restricts inverse readings to contexts in which reconstruction is possible, that is, contexts in which overt movement has occurred.[5] However, our target sentences all occur with canonical subject-before-object word order, excluding the possibility of reconstruction. We would therefore expect participants to only answer with 'yes' to Q-SR, which targets the surface $\exists\forall$-reading, but 'no' to Q-IR for the inverse $\forall\exists$-reading. This prediction holds across all six conditions since the linear order and hierarchical relationship of subject and object does not change. Thus, neither the factor *plausibility* nor the factor *embedding* should have an impact on the expected response patterns.

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[4] Strictly speaking, this condition was not unambiguous since there are still two QPs that can take scope over each other. However, in this order, the universal has a very strong tendency to take wide scope since it is preferably interpreted as distributive. Additionally, the inverse $\exists\forall$-reading entails the surface $\forall\exists$-reading so that it can be constructed as a special subcase of the surface $\forall\exists$-reading; cf. Reinhart (2006) for extensive discussion. As can be seen in the results section in Chapter 2.3, items in this condition were indeed treated as unambiguous, as expected.

[5] As indicated above, Frey's account does not make a concrete prediction for our concrete target sentences since these contain expressions that are not truly quantificational according to Frey. However, as discussed above, it is not clear to us that there is a categorical distinction in the referential potential of such QPs and the *bona fide* quantifiers used by Frey (1993), and the use of the reduced weak indefinite form *'ne* further diminished the risk of a non-quantificational referential interpretation for the $\exists$-subject QP. For these reasons, we will continue to treat *'ne* and *jeder* as *bona fide* quantifiers, as is standardly done in in the literature on quantifier scope in English; see e.g. May (1977), Fox (2000), Reinhart (2006), among many others.

Pafel's (2005) account is based on a multitude of factors with a cumulative impact on scope interpretation. In (15), we present the values for the different factors listed in Pafel (2005) for the syntactic configuration in our target sentences.

(15)   … und tatsächlich hat dann 'n breiter Kanal jedes Feld bewässert.
         … and then, indeed, a wide canal irrigated every field.
         QP1 ($\exists$-subject):   linear order: 1.5x5 + grammatical function: 1x5 = 12.5
         QP2 ($\forall$-object):   distributivity: 1x5 = 5

The $\exists$-subject QP1 has the advantage of linear order because it precedes the $\forall$-object QP, and of its grammatical function because, as the subject, it is more prone to take wide scope than the object. The $\forall$-object QP2 only has the advantage of being inherently distributive. The difference between the two values is 7.5, which is greater than five. Therefore, the sentence should be unambiguous with QP1 taking wide surface scope over QP2. Since the factors listed by Pafel remain stable across our six conditions, we expect the same answer pattern throughout. Additionally, Pafel takes QPs to be phrase-bound, which would only strengthen the unavailability of the inverse reading in the two embedding conditions. Since Pafel's account is multifactorial, it might always be possible to add further factors to the system, should these factors turn out to play a role in interpretation. Therefore, a difference between the neutral and the IR-biased condition in the 0-emb sentences might be consistent with Pafel's account if we were to include a context factor of plausibility in the system.

Finally, Bobaljik & Wurmbrand's (2012) account is based on the covert syntactic operation of Quantifier Raising and on the soft economy constraint ScoT. It predicts that inverse readings in German are unavailable in most syntactic configurations, namely whenever overt movement is licit in order to satisfy ScoT. Inverse readings should hence be available only in special contexts in which overt movement is ruled out by general syntactic constraints or in which ScoT stands in opposition to other, e.g. information-structural constraints. However, the grammaticality of (16) shows that overt movement is possible in our target sentences.

(16)   Die Polizei hatte vor dem Sturm davor gewarnt, dass **die Wege** in die Innenstadt durch Bäume blockiert werden könnten, und tatsächlich hat dann **jeden Weg**₁ ´n Baum t₁ blockiert.[6]
         *The police warned before the storm that the access roads to the city centre could be blocked by fallen trees and then, indeed, a fallen tree blocked **every access road**.*

In fact, as already argued above, overt movement should even be preferred for information structural reasons, as it would give rise to a topic-before-focus sequence: after all, the contextually salient set of access roads denoted by the DP *die Wege* 'access road' seems to be the aboutness topic of both context and target sentence. Thus, we can exclude the possibility that there is any pressure from information structure that would counter the effect of ScoT by forcing the canonical word order, quite unlike in cases of inverse scope with canonical word order under the rise-fall contour discussed in Krifka (1998). Given all of this, the account in Bobaljik & Wurmbrand (2012) also predicts inverse readings to be unavailable for our target

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[6] We changed the word ‚Zufahrt' (= entrance) to 'Weg' (= way) for this example in order to avoid garden path effects due to case ambiguity with feminine nouns in German.

sentences. In addition, their account is purely structural in that pragmatic plausibility considerations are not mentioned as a potential constraint triggering a violation of ScoT. Therefore, the account does not predict a difference between the neutral and the IR-biased condition. Additionally, same as in Pafel's account, the two embedding conditions should likewise block inverse readings from occurring, as the syntactic movement operation of QR cannot apply across island boundaries. However, given that their account does not predict any yes-answers to the IR-question in the 0-emb condition to begin with, the answer patterns should be stable across the three embedding conditions: Q-IR should be consistently answered with 'no'.

2.3. Results

The descriptive results of the experiment are shown in Figs. 1 and 2. Fig. 1 shows the proportion of *yes*-responses when participants were asked for the surface reading with Q-SR. Fig. 2 shows the same for Q-IR targeting the inverse reading. Table 1 gives the numbers for the filler/control conditions. As can be seen in Table 1, participants behaved as expected on all five filler/control conditions in overwhelmingly opting for the single available interpretation (between 89% and 95%). This shows that our experimental design is ecologically valid and yields reliable results.[7]
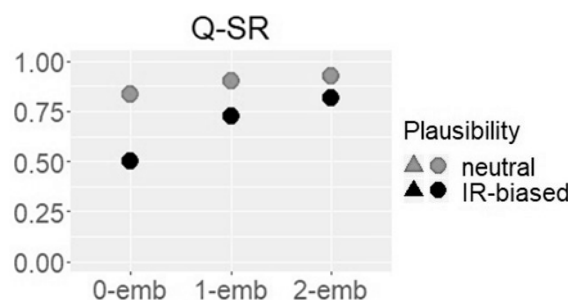
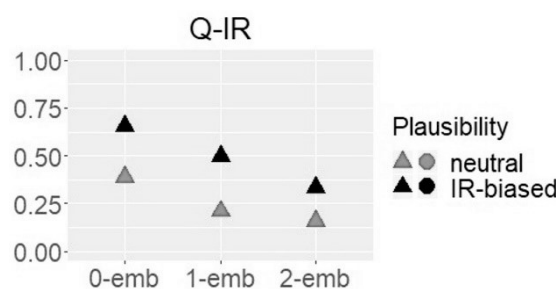

Figure 1: proportion of *yes*-answers to Q-SR

Figure 2: proportion of *yes*-answers to Q-IR

	no ∀	no ∀, 2-emb	referential	each	∀ > ∃
Q-SR	**94%**	**95%**	**94%**	8%	12%
Q-IR	10%	11%	11%	**89%**	**95%**

Table 1: proportion of *yes*-answers across all filler/control conditions

Looking at Fig. 1, we see that participants accepted the surface reading in 82% of the cases in neutral contexts without embedding (neutral/0-emb), whereas the inverse reading was still accepted in 39% of the cases. When the target sentence was embedded in a relative clause (1-emb), the surface reading was accepted in 88% of all cases, whereas acceptance of the inverse went down to 21%. When the sentence was doubly embedded (2-emb), the surface reading was accepted in 92% of all cases, whereas acceptance of the inverse reading went down still further to 16%. In condition *IR-biased*, in which plausibility considerations biased strongly towards

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[7] In addition, the filler/control conditions allow us to gauge the level of expected variability, which is presumably due to confounding non-linguistic factors beyond experimental control, such as e.g. inattention or tiredness of the participants or accidental incorrect choices on the keyboard. As the acceptance rating for the unavailable readings vary between 8% and 12%, we set the threshold of expected variability at about 10%.

the inverse reading, participants accepted the surface reading in 49% of all cases and the inverse reading even in 65% of all cases without embedding. In condition 1-emb, the surface reading was available in 71% of all cases, whereas acceptance of the inverse reading was still at 50%. In condition 2-emb, the surface reading was available in 81% of all cases, and the inverse reading was acceptable in 35% of all cases.

The data was analysed in the free software R (version 3.6.1; R Core Team, 2019) with a generalized linear mixed model fit by maximum likelihood using the package lme4 (Bates et al., 2015). (17) shows the formula for the model. The factor *plausibility* was analysed using a treatment contrast with *neutral* as the baseline. The factor embedding was analysed using a sliding contrast, comparing the 1-emb to the 0-emb condition, and the 2-emb to the 1-emb condition.

(17)   Formula: interpretation ~ plausibility * embedding + (1 | participant) + (1 | item)

We observed a main effect of the factor *context plausibility* with the IR-biased condition being significantly different from the neutral condition (p = 2.19e-11). We also observed a main effect of embedding with 1-emb being significantly different from 0-emb (p = 2.92e-13) and 2-emb being significantly different from 1-emb (p = 1.21e-06) in the neutral condition. We did not find any significant interaction effects (neutral/IR-biased & 0-/1-emb: p = 0.47; neutral/IR-biased & 1-/2-emb: p = 0.19), which would have been indicative, for instance, of an absolute blocking of inverse scope readings from embedded environments.

2.4. Discussion

The uniform prediction of all three theoretical accounts quantifier scope in German from §1 was that inverse readings should be ruled out in all six conditions of our experiment. This is clearly not the case! First of all, the acceptance rates for all the conditions are way above the expected level of ~10% from the filler/control conditions. That is, the acceptance rates indicate that participants did quite frequently obtain the inverse reading, and that this was the case across all conditions. Most importantly, participants accepted the inverse reading to a considerable degree even in neutral contexts, where the surface reading was just as plausible as the inverse reading. That is, participants were not urged into that interpretation by pragmatic considerations, a finding which is at odds with proposals that inverse readings are costly and in need of pragmatic licensing by plausibility considerations (Reinhart 2006). Even though the acceptance rate for the surface reading exceeds that for the inverse reading in the neutral condition, thereby indicating that the surface reading is generally preferred, presumably on structural grounds, the inverse reading was not excluded. This can be seen, for instance, by the acceptance rate of 39% in condition neutral/0-emb.

    Yet more remarkable is the finding that the acceptance of inverse scope readings did not drop to the same level as the filler/controls in the neutral embedding conditions, in which inverse readings should be ruled out for the simple reason that the lower QP is embedded in a relative clause island. Even though there is a clear effect of embedding in the predicted direction, i.e. the values decrease with ever deeper embedding, the inverse scope reading is still accepted to some degree, namely in 21% and 16% of all cases. Our findings on the embedding conditions thus pose a challenge to two common assumptions on inverse scope: assuming, first, that inverse readings are obtained via a covert movement operation of QR, and, second, that

relative clauses constitute islands for movement (overt or covert), the 21% acceptance of inverse readings in the neutral/1-emb condition is surprising. This would seem to suggest that either inverse readings are not obtained via QR, or that relative clauses do not actually constitute islands for movement (for similar claims see e.g. Sauerland, 2005; Hulsey & Sauerland, 2006; Barker, 2019). Interestingly, there appears to be a third option that would allow one to maintain both assumptions, however. On Sauerland's (2003) syntactic analysis of English relative clauses, these structures can have two different derivational histories in terms of *raising* or *matching*, where the relevant subtype for the discussion at hand is the subtype of raising relative clauses. According to Sauerland (2003), the NP-head in raising relative clauses originates inside the relative clause – somewhat comparable to overt head-internal relative clauses – from where it raises to its surface position. The empirical evidence for this came from reconstruction effects with condition A. Notice that the relative scope dependency in our embedding conditions was always between an existential head-NP and a $\forall$-object inside the relative clause. If so, relative clauses might very well allow for inverse readings, at least in this particular configuration, given that the existential head NP can reconstruct to its base position inside the relative clause; see also Fox (2000) on quantifier lowering. In a second step, the $\forall$-object QP could move to a position c-commanding the reconstructed $\exists$-subject QP inside the relative clause. Both steps are schematically shown in (18ab).

(18)   a. *Step 1: Reconstruction*
            There was [a~~drone~~] [which [a drone] surveilled every building].
        b. *Step 2: Quantifier Raising*
            There was [a~~drone~~] which [every building] [a drone] surveilled [~~every building~~].

Since two covert movement operations are required for deriving the inverse reading in (18), such readings would be costly and predicted to occur only rarely, if at all. In any event, their generation would be supported by plausibility considerations, which appears to be reflected in the much higher acceptance rates in conditions *IR-biased/1-emb* and *IR-biased/2-emb*. On a more sceptical note, though, it is questionable whether participants will posit such complex derivational histories in the absence of structural or pragmatic evidence, i.e. when the surface reading is easily available as an alternative and less costly reading; but see Wurmbrand (2018) for syntactic derivations of inverse scope from embedded clauses that also involve three derivational steps. Additionally, it is not clear that the raising structure postulated for English relative clauses is also found with German relative clauses. We will therefore delegate this issue to future research.

   As for the importance of world knowledge and plausibility considerations, these factors were largely ignored by treatments of quantifier scope in German. The general prediction was that inverse readings should be unavailable in the structural configuration under discussion, independent of context. The reasoning behind this is as follows: if inverse scope readings are ruled out on general structural grounds, for instance scope rigidity, then an IR-biasing context should not be able to save them. However, we have seen that inverse readings are in principle available between $\exists$-subject QPs and $\forall$-object QPs. Given this, and assuming that inverse scope readings are costlier to compute than surface readings (Reinhart 2006, Wurmbrand 2018), it is not surprising that the change of context from *neutral* to *IR-biased* had a strong effect on interpretation. In fact, IR-bias induced a preference for the inverse reading over the surface reading in the 0-emb condition. More generally, the acceptance rate of inverse readings under IR-bias is consistently higher than in neutral contexts across all conditions. The effect of

IR-bias is thereby visible even in the embedding contexts, which disfavour the inverse reading on structural grounds. Form a cross-linguistic perspective these results are in line with previous work on quantifier scope in English, which assigned context and world knowledge an important role in the interpretation of scope ambiguities (e.g. Kurtzman & MacDonald 1993, Villalta 2003, Anderson 2004, Reinhart 2006).

Taking stock, our results are not compatible with any of the existing theoretical accounts of relative quantifier scope in German, which are all based on introspective judgments. They are, by contrast, fully compatible with previous experimental research on quantifier scope in German, which found inverse readings to be available in other structural configurations than the ones tested here, and they are also compatible with the findings in Zimmermann (1997). Moreover, our results are also compatible with introspective and experimental findings on quantifier scope in English. In sum, then, our experimental results constitute strong additional evidence that inverse readings – albeit dispreferred – are in fact generally available in German, same as in English. Contrary to received wisdom, this opens up the possibility that the difference in quantifier scope potential between English and German is more gradual than categorical in nature.

3. By-Participant Variability

Closer analysis of the results also revealed a high variability in by-participant behaviour. This is illustrated in Figure 3, in which the rows in the diagrams show the response patterns of individual participants.
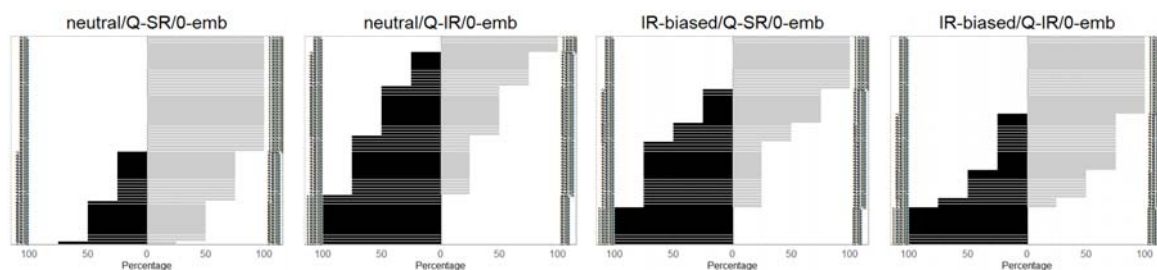

Figure 3: proportions of 'yes' (grey) and 'no' (black) in percentage by participants across all four 0-emb conditions.

The patterns are relatively stable across participants in the neutral condition with Q-SR targeting the surface reading (leftmost diagram), suggesting that the surface reading is available for the majority of participants. In all other conditions, by contrast, the response patterns are much more varied, as shown by the different distribution of 'yes'-answers (in grey) and 'no'-answers (in black) across participants. In fact, proportions of *yes*-responses are spread across the whole scale from 0 to 100%. This shows that for a given condition, some participants showed across-the-board acceptance and others showed across-the-board rejection of inverse scope and surface scope reading, respectively. Taking a closer look at the participants' individual behaviour across all conditions, there appear to be different interpretation strategies at play. Table 2 gives an overview of the prototypical behavioural patterns that could be observed, together with the rough number of participants falling into each category.
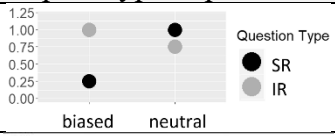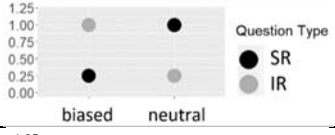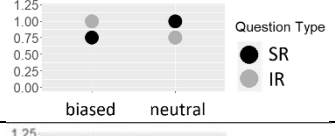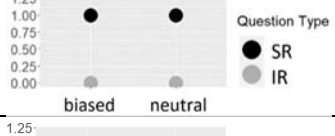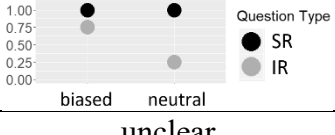
	prototypical pattern	strategy	availability of IR	number of participants
1		pragmatic	available	~17
2		pragmatic	not available/ dispreferred	~12
3		syntactic	available	~8
4		syntactic	not available	~13
5		syntactic	dispreferred	~10
6	unclear	-	-	~7

Table 2: Visually extracted patterns of participants' interpretation strategies in the 0-emb conditions

The majority of participants (60/67) could be assigned to one of these categories. We extracted two parameters that seem to play a role: first, for some participants (groups 2, 4, 5) the inverse reading seems to be categorically ruled out or extremely dispreferred, while for others, the inverse reading is generally an option (groups 1,3). Notice that it is a valid hypothesis that the authors of the introspection-based accounts of quantifier scope in German belong to this category as well. Second, some participants seem to be more syntactically driven, while others are more pragmatically driven. We will exemplify this difference by looking at groups 1 and 4 in Table 3. The participants in group 1 (almost) always responded to Q-IR targeting the inverse reading with 'yes', independent of context. In contrast, they (almost) always responded to Q-SR with 'no' in the IR-biased context and (almost) always 'yes' when the context was neutral. We categorized these participants as pragmatic-driven, since context has a clear impact: when a reading is plausible, it is accepted; when it is not plausible, it is rejected. Additionally, we say that for these participants the inverse reading is generally available, since they accept it even in the neutral context, in which acceptance of inverse readings is not forced by plausibility considerations. The participants in group 4, by contrast, always accepted the surface reading and they always rejected the inverse reading, independent of context. We consider these participants syntactically driven, as context has no impact on their observable response behaviour. In addition, the inverse reading is generally unavailable for them, because they even rejected it under IR-bias, in which the inverse reading was the more plausible interpretation. Notice, though, that the number of items per condition and participants was low and that we did not run a statistical analysis on by-participant variability. Therefore, the categorization in Table 3 has to be taken with caution, and they should be explicitly targeted in a separate experiment.

The more general question that arises from the observed by-participant variability is why it should exist at all. It is a common, though perhaps incorrect, assumption that speakers of the same language share the same grammar. They could therefore be expected to interpret sentences in a similar manner. Quantifier scope, too, is a linguistic phenomenon that is standardly considered to be driven by the syntactic properties of a given language. This expectation clashes with our results, which exhibit a range of possible response patterns, from one extreme to the other. One way of accounting for this quite drastic variability would be to say that speakers of the same language, or even the same dialect, exhibit micro-variation regarding subtle and relatively infrequent grammatical phenomena such as quantifier scope. While most rules of grammar are shared, intuitions may well differ on more marginal phenomena. Alternatively, or additionally, the variation may also be accounted for by postulating transfer effects and differing exposure to other languages. In English, for instance, inverse readings are generally claimed to be more easily available than in German. Some studies have shown that it is possible for L2-learners to learn the scope properties of the target-language even when they differ from the native language (Marsden, 2004; Lee, 2009). Thus, scope preferences may not be fixed but may well change in response to different language exposure. It is therefore conceivable that participants could differ in their proficiency of English, thereby exhibiting different degrees of transfer effects. Finally, it is possible that quantifier scope is a phenomenon that is not so much affected by grammatical constraints but has more to do with processing abilities. In fact, inverse scope is typically described to be costlier (e.g. Reinhart, 2006; Kurtzman & MacDonald, 1993). The variable response patterns might thus be a consequence of different levels of processing abilities. These possibilities should be investigated in future experiments.

4. Conclusion

We presented the results of an offline behavioural experiment on quantifier scope in German that provides strong evidence that inverse scope readings are in fact available in German – albeit dispreferred. These findings stand in stark contrast to the existing theoretical literature on quantifier scope in German, which is largely based on introspection data (Frey, 1993; Pafel, 2005; Bobaljik & Wurmbrand, 2012). We also showed that both context plausibility and island embedding have a strong effect on scope interpretation. Interestingly, the data suggests that inverse scope readings are not completely banned from relative clause islands. Our experiment also showed that speakers of the same language exhibit highly variable behaviour when it comes to the interpretation of relative quantifier scope. This variability is likely not random, as it appears to be driven by different interpretation strategies which give higher priority to structural or pragmatic considerations (plausibility), respectively.

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