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# How clausal linking affects noun phrase salience in pronoun resolution

## 1 Introduction

A central research aim in language processing is to understand the mechanisms that assign anaphors to their referents. In many cases a referent of an anaphor is unambiguously identified by grammatical features like gender and number marking, e.g. *Mary<sub>i</sub> met Max in a café because she<sub>i</sub> . . .* However, in a case like *Fred met Max in a café because he . . .* the assignment of a referent for *he* is less straightforward. Reference resolution investigates how an anaphoric pronoun (like *he*) is mapped to a target referent among a list of candidates (like *Fred, Max*).

It is generally agreed that salience affects ambiguous reference resolution. The concept of salience originates from cognitive psychology and describes a state of prominence of an item in relation to other items in context. It is assumed that salience guides the attention and thus helps individuals to rank large amounts of information by importance. In psycholinguistics, salience is often used as a cover term for (cognitive) availability or accessibility. For instance, it is claimed that a salient item (in comparison with an item that is less salient) is more accessible in memory and thus a more likely candidate to act as a referent for an anaphoric pronoun (Ariel 1990; Gundel, Hedberg, and Zacharski 1993 among others). (In contrast McElree and Foraker 2007 argue that salience increases availability, but not accessibility in memory.)

Psycholinguistic studies revealed a range of linguistic and cognitive factors that influence the salience of an item. (For an overview see for instance Prince 1981; Ariel 1990; Givón 1983; Gundel, Hedberg, and Zacharski 1993; Arnold 1999.) The results support a multiple-constraint approach whereby the salience level of an item is believed to be a consequence of syntactico-semantic features as well

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as the mental representation of the discourse (e.g. Kaiser and Trueswell 2008). Hence, a line of recent research on pronoun interpretation is dedicated to certain aspects of discourse processing. In particular, it is investigated how the discourse-relational structure directs attention and thus influences reference resolution (e.g. Holler and Irmen 2006; Kertz, Kehler, and Elman 2006; Kehler et al. 2008; Kaiser 2009; Kehler and Rohde 2013).

If discourse relations are explicitly marked they may be expressed with a connective that combines two consecutive clauses. Usually, the semantics of the connective defines the discourse relation, however, discourse relations may also be implicit. In this case, the implicit causality information of the verb describing the main event of the first clause may establish a causal discourse relation (Garvey and Caramazza 1974; Garvey, Caramazza, and Yates 1974; Garnham et al. 1996; Bott and Solstad 2014; Hartshorne 2014). Implicit causality of a verb biases pronoun interpretation and, thus, may enhance the salience of an antecedent candidate of an anaphor.

Implicit causality of certain verbs assigns the causal role of an action to either the subject or the object, for example in:

- (1) Fred frightened Max because he . . .

*Fred* is the cause for *Max* to be *frightened*. The following pronoun is most likely to refer to the cause of the state. Whereas in:

- (2) Fred feared Max because he . . .

*Max* somehow caused *Fred* to be fearful. Therefore, in (2) *he* is more likely to refer to *Max*. Following Brown and Fish (1983a, 1983b) and Rudolph and Försterling (1997) verbs like *frighten* will be referred to as S-E verbs (subject-experiencer) and verbs like *fear* as E-S verbs (experiencer-subject). The implicit causality information of a verb has been shown to change the salience of the subject: with an S-E verb like *frighten* the subject noun is salient and thus the preferred referent for a pronoun; an E-S verb like *fear*, on the other hand, reduces the salience of the subject increasing the prominence of the object noun in discourse (Grober, Beardsley, and Caramazza 1978; Koornneef and van Berkum 2006; Majid, Sanford, and Pickering 2007; Fukumura and van Gompel 2010; Pyykkönen and Järvikivi 2010; Cozijn et al. 2011; Koornneef and Sanders 2013; among others).

Interestingly, properties of the clausal linking connector that precedes the anaphor can also affect the salience of its antecedent (Grober, Beardsley, and Caramazza 1978; Majid, Sanford, and Pickering 2007; Fukumura and van Gompel 2010; Ellert and Holler 2011; Koornneef and Sanders 2013). Grober, Beardsley, and Caramazza (1978) have shown that with a contrastive connector like *but* the

verb's implicit causality effect can disappear. Information provided by a connector can either be consistent (e.g. *because*, *and*) or inconsistent (contrastive like *but* and concessive like *although*) with the interpretation of the main clause. If interpreted as a denial of expectation (Umbach and Stede 1999) a contrastive connector can reverse the noun phrase preference from the main clause. In *Fred feared Max because he . . .* the preference for the NP2 *Max* (due to the E-S-verb) remains unaffected by the causative connector *because*, while in *Fred feared Max but he . . .* the initial preference to refer to the NP2 is reversed by the contrastive connector *but*. Hence the semantic content of connectors can change the noun phrase preference and thus also the salience of a noun phrase. According to their power to change the noun phrase preferences, the contrastive connector *but* and the concessive connectors *although* will be referred to as strong and the causative connector *because* as weak in this paper.

Kehler et al. (2008) argued that ambiguous pronoun resolution is also affected by discourse coherence. They investigated whether resolution processes could be influenced by the type of continuations (or whether the continuation is within the same or another discourse unit as was discussed by De la Fuente et al. 2016). Using IC (implicit causality) and non-IC verbs, an initial sentence sets a discourse and therefore an expectation about a continuation. This might be elaborated in a clause introduced by *because* or with a new sentence that has no initial indicator that provides additional information. They found that the continuation type (either a clause with connector *because* or a new sentence) did not affect the IC preference for the anaphor antecedents set by the verb. More explicitly, the probabilities to refer to either the NP1 or the NP2 (dependent on the IC preferences) did not differ when the anticipated information was presented in a clause starting with *because* and when the information was presented in a completely new sentence without semantic linking information.

Thus, the findings of Kehler et al. (2008) indicate that the semantic information of a connector does not affect noun phrase preferences when it is coherent in discourse. The fact that there is no difference between the connector condition and the new sentence condition suggests that *because* could be omitted and the noun phrase salience would be unchanged. However, how would a different connector affect the explanation expectations and therefore the noun phrase preference? Since *because* agreed with the discourse expectations, it did not affect the IC preference and there was no effect of clausal linking.

Following the discussions of Kehler et al. (2008) and the previously discussed findings about contrastive connectors and their effect on noun phrase salience, we are interested whether connectors (e.g. *but*, *although*) that violate expectations set by the discourse could affect the IC preferences. This provides further motivation for our previous definition of the connector types: connectors that confirm an ex-

pectation do not affect IC preferences and are weak. This term is used in relation to their low semantic impact on the IC preferences. Connectors like *but* or *although* might interact stronger with the IC effect and therefore are referred to as strong in this paper.

Current research in theoretical linguistics has shown that clausal linkage is a multidimensional grammatical phenomenon. In complex sentences, clauses must be distinguished in terms of the degree they are integrated into a potential host clause depending on their syntactic form, their interpretation, and their functional usage (cf. König and van de Auwera 1988; Fabricius-Hansen 1992; Reis 1997; Holler 2008; Frey and Truckenbrodt 2015). It is generally agreed that the grammatical properties of connectors are crucial for clause combining and that they can induce different types of clausal structures. In most theoretical analyses this is reflected by the way a clause headed by a connector is syntactically combined with its matrix clause. Leaving theoretical details aside, both clauses can either be coordinate or the second clause is embedded and thus subordinate to the matrix clause. These differences in clausal structure may influence discourse segmentation. While it is usually assumed that a subordinate clause is part of the same discourse segment as its matrix clause, coordinated clauses can be part of two different discourse segments depending on the connector used (Haegeman 1991; Gärtner 2001; Holler 2008).

Miltsakaki (2003) investigates the effects of clausal structure on attention structure in discourse processing. She assumes that the second clause in a complex sentence can either be a subordinate clause when used with connectors like *although* and *when* or a coordinate main clause when used with *however* or *then*. Even though a contrastive connector should reverse the noun phrase preference from the first clause, Miltsakaki (2003) showed that this effect is reduced when the connector is in a subordinate clause. Thus, while connectors can affect the resolution preference for a pronoun, structural constraints of the connectors can modulate that effect. According to Miltsakaki (2003) the semantic content of a connector from a subordinate structure should have less of an impact on the interpretation of the main clause than the content of a connector from a coordinate main clause (but see also De la Fuente and Hemforth 2016).

Ellert and Holler (2011) tested the influence of clausal linking with a sentence completion experiment in German. Subordinate and coordinate clauses are especially marked by the position of the verb in German. In subordinate clauses, the verb appears at the end of the sentence (*Ben weinte, da / weil Max das Spielzeug verloren hatte. Er . . .*), while in main clauses the verb is in the second position (*Ben weinte, weil / denn Max hatte das Spielzeug verloren. Er . . . / 'Ben cried because Max had lost the toy. He . . .'*) (Ellert and Holler 2011: 166). However, Ellert and Holler (2011) reported that there was no effect of sentence structure on ref-

erential choice. This might be because they manipulated only the accessibility of the NP2 (*Max*) while the state of the NP1 remained constant over all conditions. However, these findings are noteworthy since the causative connective *weil* ‘because’ can be used at the beginning of a subordinate (. . . , *weil Max das Spielzeug verloren hatte.*) as well as at the beginning of coordinate clause (. . . , *weil Max hatte das Spielzeug verloren.*) in German. This might indicate that the syntactic structure is not a main factor in anaphor resolution. It might interact with something else, maybe semantic information of the connector.

We assume that clause linking operators like connectors have their own semantic and structural properties in a discourse. In ambiguous anaphor resolution these properties are expected to affect the salience of an antecedent noun, which might make that a more likely candidate to be retrieved from memory and consequentially assigned as the anaphor referent. This leads to the questions: How do the semantic and structural properties of connectors affect noun phrase salience in discourse? What does this mean for discourse segmentation?

We present two sentence completion studies that investigate the effect of clausal linking properties on noun phrase salience in German. Both experiments contrast weak (*weil, denn* ‘because, since’) with strong (*aber, obwohl* ‘because, although’) connectors following a main clause with IC verbs (S-E verbs: subject-experiencer verbs and E-S verbs: experiencer-subject verbs). The structural properties of these connectors allow them to be either presented in a subordinate clause (*weil, obwohl* ‘because, although’) or in a coordinate clause (*denn, aber* ‘since, but’). In Experiment 1, participants had to finish a sentence after an ambiguous pronoun *er* ‘he’ and the content of their continuations was interpreted to either refer to NP1 or NP2 of the preceding clause. In Experiment 2, participants were asked to complete a sentence after the connector using either a pronoun or a full name expression. The referent participants had to refer to was underlined in the preceding clause. The initial assumption was that participants would be more likely to chose the pronoun to refer to the salient noun phrase and the full name expression for the less salient antecedent.

Thus, Experiment 1 investigated effects on salience of NP1 and NP2 by the number of references to these entities in an ambiguous setting. The salience of noun phrases in Experiment 2 was investigated by the choice of referring expressions for NP1 or NP2.

## 2 Experiment 1

Experiment 1 investigated the effects of salience for ambiguous pronoun resolution. Verb causality has long been known to affect noun phrase salience. We used the verb causality effect to investigate how connector properties (semantics and structure) can affect noun phrase activations set by the verb. Following the discussions from the introduction above we predict that semantic and structural properties of connectors will affect the IC preferences set by the verb. In discourse structure (Kehler et al. 2008), strong connectors like *aber*, *obwohl* ‘but, although’ violate expectations set by the precursor. We therefore hypothesise that the IC preference for either NP1 (S-E verb) or NP2 (E-S verb) will be reduced with strong connectors (*aber*, *obwohl* ‘but, although’) in comparison to weak connectors (*weil*, *denn* ‘because, since’). Thus, e.g. the preference to refer to the NP1 with an S-E verb (*ängstigen* ‘frighten’) will be smaller with a strong connector (*aber*, *obwohl* ‘but, although’) than with a weak connector (*weil*, *denn* ‘because, since’).

Clausal linking connectors mark the structure that the information is presented in: *weil* ‘because’ and *obwohl* ‘although’ introduce a subordinate clause and *aber* ‘but’ and *denn* ‘since’ introduce coordinating main clauses. According to Miltsakaki (2003), sentence structure types influence the impact of their information on the overall discourse. Following this, we predict an interaction between semantic and structural factors of a connector on IC preferences of the verb. We predict that strong connectors reduce the IC preferences of the verb, thus this effect should be even more pronounced when the strong connector is in a coordinate clause than when it is in a subordinate clause. We thus predict a three-way interaction between *verb type* × *connector semantics* × *structural information* for Experiment 1.

### 2.1 Method

#### 2.1.1 Materials, design and procedure

Twenty-four experimental items were constructed each beginning with a main clause of the type: NP1 verb NP2. The NPs were proper names (e.g. *Knut*, *Lars*) which were matched within items for their number of syllables in order to avoid that by their length one name would be more visually salient than the other name. The verb was either an S-E verb (stimulus-experiencer, e.g. *ängstigen* ‘frighten’) or an E-S verb (experiencer-stimulus, e.g. *fürchten* ‘fear’). The verbs were taken from the materials section from Härtl (2001), which rated 11 verbs as S-E verbs and 13

verbs as E-S verbs. (Due to a construction error, the distribution of S-E and E-S verbs was not fully balanced. This was not considered to be problematic, as in ambiguous pronoun resolution it is generally predicted that there is a preference to resolve pronouns towards NP1. Thus, if verb causality had an influence, this error increased the tokens for which a deviant behavior would be observable.) The first main clause was followed by either a strong (*aber*, *obwohl* ‘but, although’) or a weak (*denn*, *weil* ‘since, because’) connector. While connectors like *aber* ‘but’ and *denn* ‘since’ are assumed to coordinate two main clauses, the other two types of connectors, *weil* ‘because’ and *obwohl* ‘although’, introduced a subordinate clause. The connector was followed by the pronoun *er* ‘he’ and participants were to finish the sentence from this point on.

The design of Experiment 1 was a 2×2×2 design. Factor A in the design is the *implicit verb causality* of the first verb (S-E versus E-S verbs); Factor B is the *semantic information* of the connector (strong versus weak) and Factor C is the *sentence structure* of the information (coordinating versus subordinating). Thus, each of the three factors A, B, C in the design has two levels.

**Table 1.** Conditions for Experiment 1.

1.	S-E / strong coordinating <i>Knut ängstigte Lars aber er ...</i> ‘Knut frightened Lars but he ...’	5.	E-S / strong coordinating <i>Knut fürchtete Lars aber er ...</i> ‘Knut feared Lars but he ...’
2.	S-E / weak coordinating <i>Knut ängstigte Lars denn er ...</i> ‘Knut frightened Lars since he ...’	6.	E-S / weak coordinating <i>Knut fürchtete Lars denn er ...</i> ‘Knut feared Lars since he ...’
3.	S-E / weak subordinating <i>Knut ängstigte Lars weil er ...</i> ‘Knut frightened Lars because he ...’	7.	E-S / weak subordinating <i>Knut fürchtete Lars weil er ...</i> ‘Knut feared Lars because he ...’
4.	S-E / strong subordinating <i>Knut ängstigte Lars obwohl er ...</i> ‘Knut frightened Lars although he ...’	8.	E-S / strong subordinating <i>Knut fürchtete Lars obwohl er ...</i> ‘Knut feared Lars although he ...’

Fourty-eight filler items were created and eight experimental lists were constructed following a latin-square design. The experiment was programmed as a web experiment with <https://www.soscisurvey.de/>. The stimuli were presented in a randomised order. Participants were instructed to read the beginning of the sentences and then to complete them by typing in their continuations. The referring expression *er* ‘he’ was given in Experiment 1 and participants had to finish the sentence after the pronoun.

Participants were told that they would be presented with sentence fragments. They were asked to find a suitable completion of the sentence seen so far. They should not think too long about their sentence continuation, but enter the first suitable completion that comes to mind.

### 2.1.2 Participants

Forty-eight German native speakers (34 female) participated in the study. They were all students at the University of Göttingen between the age of 20 and 33 (mean age = 24.06; standard deviation = 2.78). The sentence completion task took about 20 minutes to finish and participants received a small fee for their participation. None of the participants were excluded from the analysis of the study.

### 2.1.3 Results

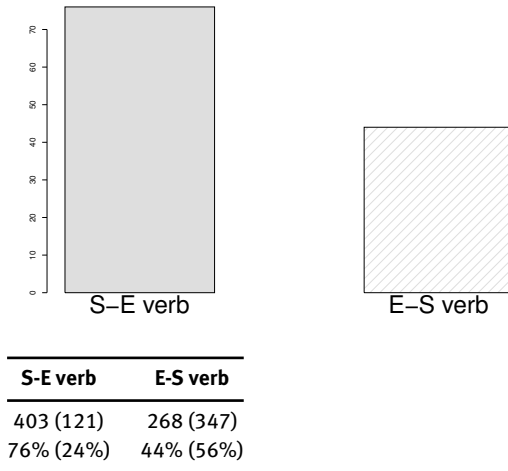
*Sentence Ratings.* The sentence completions were judged by three independent linguist expert raters. They decided whether the sentence completions after *er* ‘he’ referred either to the NP1 or to the NP2. We assessed the inter-rater reliability by calculating Fleiss Kappa which was very high with  $\kappa=0.8641$ . There were 1152 sentence completions in total. (Thirteen sentence completions needed to be excluded from the analysis, because the pronoun had been recoded by participants. One example for such a recoding is: *Emil worried Tilo, but he . . . it was supposed to be nothing more but a joke*. Some needed to be excluded, because they were either semantically implausible or the completions were grammatically incorrect.) The judgements perfectly converged on 90% of the answers ( $\pi = 1$ ), in all of the other cases one rater differed in her rating ( $\pi = 0.33$ ). In these latter cases, the answers of the two judges who agreed in their ratings entered the analysis (113 ratings in total of which: 32 were strong-coordinating, 18 were weak-coordinating, 17 were weak-subordinating and 46 were strong-subordinating).

The sentence completion data was analysed using a general linear mixed model with a logit link function on the binary choice of the referent. Fixed factors were *verb causality*, *connector type* and *sentence structure*. *Items* and *subjects* were treated as crossed random factors in the model. Model comparisons using the ANOVA function in R showed that including interactions for the fixed factors significantly improved the fit of the model. However, adding random slopes for the predictors did not add to the fit of the model. Therefore, the model with interaction terms between the fixed-effects predictors was chosen for the analysis.



There was a main effect of verb causality ( $z = 6.90$ ;  $p < .01$ ;  $SE = 0.16$ ) (see Figure 1): in their sentence continuations, participants referred more to the NP1 (76% *Knut*) than to the NP2 (24% *Lars*) with an S-E verb (*ängstigte* ‘frightened’). In addition, participants referred more to the NP2 (56% *Lars*) than the NP1 (44% *Knut*) of the previous sentence with an E-S verb (*fürchtete* ‘feared’). The analyses did not show any other main effect.

#### Reference to NP1: effect of verb-causality



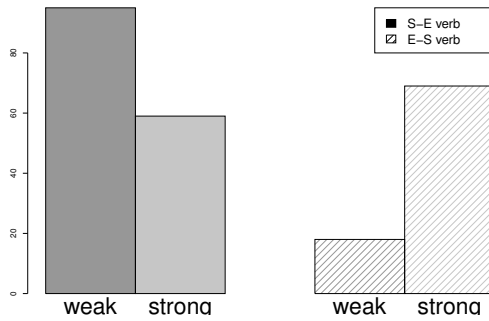
**Fig. 1.** Numbers and percentages of references to NP1 in Experiment 1. Main effect of verb causality. (Numbers in brackets are references to NP2.)

The main effect of verb causality was qualified by two interactions: (1) *verb causality* × *connector semantics* and (2) *verb causality* × *sentence structure* (see Figure 2).

The verb causality × connector semantics interaction was significant ( $z = 13.87$ ;  $p < .01$ ;  $SE = 0.10$ ). Simple effects analyses showed that with S-E verbs strong connectors (*aber, obwohl* ‘but, although’) decreased the number of NP1 references (59%) in comparison to weak connectors (95% *weil, denn* ‘because, since’) ( $z = 8.05$ ;  $p < .01$ ;  $SE = 0.17$ ) and with E-S verbs strong connectors significantly increased the number of NP1 references (69%) in comparison to weak connectors (18%) ( $z = -12.64$ ;  $p < .01$ ;  $SE = 0.12$ ).

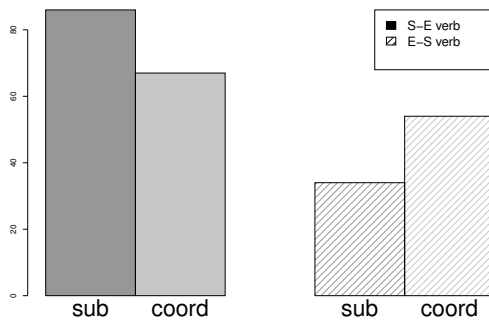
The verb causality × sentence structure interaction ( $z = -5.94$ ;  $p < .01$ ;  $SE = 0.10$ ) showed that for the S-E verb (*ängstigte* ‘frightened’) conditions, there were significantly more NP1 descriptions for the subordinate sentence conditions (86% *weil, obwohl* ‘because, although’) than for the coordinate sentence conditions (67%

## Reference to NP1: verb causality × connector



	weak	strong
<b>S-E</b>	249 (14) 95% (5%)	154 (107) 59% (41%)
<b>E-S</b>	57 (252) 18% (82%)	211 (55) 69% (31%)

## Reference to NP1: verb causality × structure



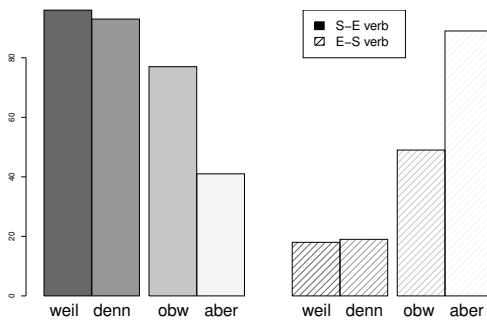
	subordinate	coordinate
<b>S-E</b>	227 (36) 86% (14%)	176 (85) 67% (33%)
<b>E-S</b>	104 (205) 34% (66%)	164 (142) 54% (46%)

**Fig. 2.** Numbers and percentages of references to NP1 in Experiment 1 (in brackets are references to NP2). Interaction verb causality × connector semantics and verb causality × sentence structure.

*aber, denn* ‘but, since’) ( $z = -3.46$ ;  $p < .01$ ;  $SE = 0.17$ ). For the E-S verb (*fürchtete* ‘feared’) conditions, however, the number of NP1 descriptions was significantly lower for the subordinate sentences (34% *weil, obwohl* ‘but, although’) than for the coordinate sentences (54% *aber, denn* ‘but, since’) ( $z = 5.492$ ;  $p < .01$ ;  $SE = 0.12$ ).

The interaction between *structure*  $\times$  *connector semantics* was not significant. In addition, there was a three-way interaction between *verb causality*  $\times$  *connector semantics*  $\times$  *structure* ( $z = 4.31$ ;  $p < .01$ ;  $SE = 0.10$ ) (see Figure 3). For sentences with a contrastive connector type, when there was an S-E verb, participants referred more to the NP1 when the sentence structure was subordinate (77%) in comparison to a coordinate sentence structure (41%) ( $z = -6.21$ ;  $p < .01$ ;  $SE = 0.14$ ). When there was an E-S verb (also in sentences with a strong connector), a subordinate sentence structure elicited fewer NP1 references (49%) than the coordinate sentence structure (89%) ( $z = 7.15$ ;  $p < .01$ ;  $SE = 0.16$ ).

### Reference to NP1: causality $\times$ structure $\times$ connector



	weak-subordinate	weak-coordinate	strong-subordinate	strong-coordinate
S-E	126 (5) 96% (4%)	123 (9) 93% (7%)	101 (31) 77% (23%)	53 (76) 41% (59%)
E-S	28 (127) 18% (82%)	29 (125) 19% (81%)	76 (78) 49% (51%)	135 (17) 89% (11%)

**Fig. 3.** Numbers and percentages of references to the NP1 in Experiment 1 (in brackets are references to NP2). Interaction verb causality  $\times$  connector semantics  $\times$  sentence structure.

Thus, the reference to NP1 is affected by the sentence structure for strong connectors. When there is a strong connector (*aber, obwohl* ‘but, although’): with an S-E verb there will be more references to NP1 in a subordinate sentence structure than in a coordinate sentence structure. However, this pattern is reversed with an

E-S verb; there were fewer references to NP1 in a subordinate than in a coordinate sentence structure.

## 2.2 Discussion of Experiment 1

As expected, we found an effect of IC verbs in Experiment 1: participants were more likely to refer to the sentence subject (rather than the object) with S-E verbs (*frighten*) than with E-S verbs (*fear*). In comparison, using E-S verbs decreased the reference to NP1 (44%), while NP2 are more likely (56%) to become the referent of the anaphor. These observations are in agreement with previous findings which claimed that verbs can assign the causality of an event to either the subject or the object of a sentence (Grober, Beardsley, and Caramazza 1978).

Interestingly however, an interaction showed that the IC verb effect was affected by the connector semantics. Strong connectors like *aber, obwohl* ‘but, although’ reduced the preference to refer to the NP1 with S-E verbs to almost chance level (59%) from 76%. In comparison, strong connectors which follow an E-S verb in the main clause increase the reference to the NP1 to 61% from the 44% of the main effect. Thus, using a strong connector can eliminate the IC verb effect. Implicit causality of S-E verbs like *frighten* marked the NP1 *Knut* of the sentence and thus NP1 will be the preferred referent of the anaphor: 76% of the sentence continuations referred to the NP1. While on the other hand, E-S verbs like *fear* are more likely to mark NP2 of the sentence. Hence, there were fewer references to NP1 in the sentence continuations (44%) with E-S verbs. However, using strong connectors like *aber, obwohl* ‘but, although’ not only significantly reduced the preference for the NP1 with S-E verbs (59%), it also increased the preference for the NP1 with E-S verbs (69%) so that the implicit causality of the verbs was reversed. Weak connectors like *weil, denn* ‘because, since’ did not affect the implicit causality of the verb. Using weak connectors, participants preferred to refer to the NP1 with S-E verbs, while the preference for the NP1 was reduced for the E-S verb making NP2 the preferred referent of the anaphor. Thus, when using weak connectors like *weil, denn* ‘because, since’ it is the implicit causality of the verb that directs the reference resolution of the anaphor. While connectors like *aber, obwohl* ‘but, although’ have the strength to overwrite preferences set by the IC verb.

In addition to the semantics of the connectors, verb causality also interacted with the sentence structure that participants used to complete the sentence. Connectors like *weil, obwohl* ‘because, although’ are more likely to be followed by a subordinate clause, while *denn, aber* ‘since, but’ initiate a coordinate main clause. The interaction showed that for S-E verbs there are fewer references to the NP1 in a coordinate main clause (67% after *denn, aber*) than in a subordinate clause (86%

after *weil, obwohl*). In comparison, for E-S verbs there were more references to the NP1 in a coordinate structure (54%) than in a subordinate structure (34%). Thus the information in a coordinate sentence structure seems of different weight than the information in a subordinate structure. The interpretation of a subordinate sentence structure seems to comply with the preference set by the implicit verb causality. S-E verbs mark the NP1 and since the information from a subordinate sentence is merely an adjunct to the main sentence, the marked NP1 is more accessible than the NP2. In contrast, the information from a coordinate sentence has more value than that from a subordinate sentence (Holler 2008). Thus, the special marking of the NP1 from the S-E verb in the first sentence will not transfer to the coordinate sentence; the NP2 of the previous sentence becomes more accessible in a coordinate sentence than in a subordinate sentence (given the first sentence used an S-E verb).

The sentence completion experiment also showed a three-way interaction which modulated the two previous interactions. The previously reported interactions showed that connector semantics and sentence structure interacted with verb causality and both independently reduced (structure – coordinate) or even eliminated (semantics – strong connectors) the verb causality effect. The three-way interaction informed these interactions: when a strong connector links two coordinate clauses together, the noun phrase preferences set by the verb will not only be eliminated, but reversed. Initially an S-E verb activates the NP1 as the reference for a potential anaphor. When this anaphor is preceded by a strong connector in a coordinate clause, NP2 will be the preferred referent for the same anaphor. The same applies for E-S verbs, a strong connector in a coordinate clause can shift noun phrase salience from NP2 to NP1.

Thus, Experiment 1 showed that clausal linking operators provide semantic and structural information which can reverse the verb causality effect. It is noteworthy here that connectors seem just as powerful as verb causality to make an item more salient in ambiguous anaphor resolution.

### 3 Experiment 2

Experiment 1 showed effects of verb causality on the referent choice for the anaphor. Interestingly, the connector semantics interacted with verb causality in Experiment 1: strong connectors reduced the references to NP1 for S-E verbs while they increased the references to NP1 for E-S verbs. However, the semantics of a connector might also affect the referring expressions that are used to describe the preferred referent. According to Ariel (1990) and Gundel, Hedberg, and Zacharski

(1993) an anaphor that is more complex is more likely to be used to refer to an entity that is harder to access in memory. Fukumura and van Gompel (2010) argued that the choice of referential expression is an indication about the referent's accessibility in memory. According to this argument, when participants chose to use a pronoun like *he* or *she*, the referent is more accessible in memory than when they use a more complex noun phrase like a proper name.

Fukumura and van Gompel (2010) tested this prediction in two sentence completion experiments. In Experiment 1 participants had to complete a sentence fragment which either contained an S-E (*scared*) or an E-S verb (*feared*) and two proper names (NP1 *Gary* and NP2 *Anna*). The referent that participants had to refer to in their description was marked (here underlined). For the reference participants could either use a pronoun (*he*, *she*) or the full proper name (either *Gary* or *Anna*). They found that NP1 had more pronoun references than NP2. However, this preference did not interact with verb causality. With S-E verbs there were not more pronoun references to NP1 than with E-S verbs.

Previous studies have shown that different types of connectors can interact with verb causality (Stevenson, Crawley, and Kleinman 1994). Stevenson, Crawley, and Kleinman (1994) reported that when testing connectors like *because* and *so* they affected the references to NP1 when there were S-E verbs. They argued that since *because* deals with the cause of an event, the stimulus with an S-E verb is more focused and therefore more likely to be referred to. Whereas a connector like *so* is more focused on the consequence and thus the experiencer was more referred to in Stevenson, Crawley, and Kleinman (1994). (This is not in agreement with Kehler and Rohde [2013], who argued that semantic factors are more likely to affect the referent choice and less likely to affect the choice of referring expressions. However, this discussion is not part of this paper.)

Following this, Fukumura and van Gompel (2010) argued that with *because* the stimulus is more in focus, hence participants should be more likely to refer to the stimulus with a pronoun than with a proper name. By the same logic, they should use more pronouns when referring to the NP2 with *so* that focuses more on the consequence. Fukumura and van Gompel (2010) tested this in a sentence completion experiment. Participants had to complete sentences which contained S-E verbs contrasting the connectors *because* and *so*. Like in Experiment 1, they had to refer to an antecedent (either NP1 or NP2 which were proper names) that was marked either using a pronoun (*he* / *she*) or the complete proper name (either *Gary* or *Anna*).

Even though they found two main effects – (1) an effect of antecedent (more pronoun expressions for NP1 than NP2) and (2) an effect of the connective (more pronouns after *because*) – there was no interaction. Thus, according to the findings of Fukumura and van Gompel (2010), there was no indication that the type

of connector affects the choice of referring expression when describing either NP1 or NP2.

Experiment 1 showed that noun phrase salience is affected by structural and semantic properties of the clausal linking connector. Not only can clausal links eliminate the antecedent preference set by the IC verb, strong clausal links in a coordinate clause can even reverse the preference for one noun phrase to the other noun phrase.

Stevenson, Crawley, and Kleinman (1994) and Fukumura and van Gompel (2010) investigated the connector semantics of anaphoric choice for S-E verbs only. The reported interaction between verb causality and connector semantics of Experiment 1 in this paper suggested that connector semantics can also affect the number of NP1 references for E-S verbs (there were more NP1 references with strong connectors than with weak connectors in E-S verbs). The fact that Fukumura and van Gompel (2010) investigated the choice of referring expressions for S-E verbs only and our finding in Experiment 1 that E-S verb preferences (as well as S-E verbs) are affected by clausal linking operators motivated Experiment 2.

Experiment 2 investigated whether semantic and structural properties of the clausal linking connector could affect the choice of referring expressions for S-E verbs and E-S verbs (pronoun vs. full name description). This is similar to Fukumura and van Gompel (2010), but with a design that also investigates the connector properties for both types of IC verbs (S-E and E-S verbs).

Fukumura and van Gompel (2010) argued that a connector's semantic properties have an effect on the accessibility of possible pronoun antecedents: a more activated and accessible noun would be more likely to be referred to with a pronoun than with a full noun phrase. Experiment 2 further investigates how noun phrase accessibility can be affected by properties of clausal linking connectors and verb semantics.

We expect to find similar results to Fukumura and van Gompel (2010): a main effect of antecedent and no effect of the S-E verb. However, since Experiment 1 showed that connector properties can affect E-S verbs, we expect that connector semantics affect the choice of referring expressions for E-S verbs: strong connectors should decrease the NP2 preference set by the E-S verb. That means that there should be fewer pronoun expressions to refer to the NP2 with a strong connector than with a weak connector for E-S verbs.

## 3.1 Method

### 3.1.1 Materials, design and procedure

The same 24 experimental items from Experiment 1 were used in Experiment 2. However, unlike in Experiment 1, the pronoun after the connector was not given in Experiment 2. Participants had to finish the sentence after the connector using a referring expression of their choice (either a proper name *Knut*, *Lars* or the pronoun *er* ‘he’). One referent was underlined to signal which referent the participants had to refer to after the connector, e.g. in (1)–(8) in Table 2 participants had to refer to *Knut* with a referring expression of their choice and in (9)–(16) participants had to refer to *Lars*. Like in Experiment 1, the main clause contained two proper names and either an S-E (subject-experiencer) or an E-S (experiencer-subject) verb. The first clause was followed by either a strong (*aber*, *obwohl* ‘but, although’) or a weak (*weil*, *denn* ‘because, since’) connector. While the connectors *aber* ‘but’ and *denn* ‘since’ introduced a main clause, *weil* ‘because’ and *obwohl* ‘although’ usually introduce a subordinate clause.

Thus, Experiment 2 introduces another factor (Factor D) in comparison to Experiment 1: the antecedent of the reference. Either the NP1 or the NP2 in the main clause was marked and participants had to refer to the underlined NP in their sentence continuations. Thus Factor D also had two levels and Experiment 2 had a 2×2×2 design. Participants were free in their choice of referring expressions, they either could use a proper name (*Knut*, *Lars*) or the pronoun (*er* ‘he’).

### 3.1.2 Participants

Ninety-six native speakers of German (66 female) participated in Experiment 2, the data of all participants were analysed. (There were eight conditions in Experiment 1, compared to the 16 conditions in Experiment 2. Because the number of conditions differed, we also changed the number of participants. Similar to the conditions, we doubled the amount of participants in Experiment 2.) They were students of the University of Göttingen between 19 and 41 years of age (mean age = 23.35; SD = 3.56). The experiment lasted about 20 minutes and participants received a small fee for their participation.



**Table 2.** Conditions for Experiment 2.

1.	NP1 / S-E / strong / coord <i><u>Knut</u> ängstigte Lars aber ...</i> ' <u>Knut</u> frightened Lars but ...'	9.	NP2 / S-E / strong / coord <i>Knut ängstigte <u>Lars</u> aber ...</i> 'Knut frightened <u>Lars</u> but ...'
2.	NP1 / S-E / weak / coord <i><u>Knut</u> ängstigte Lars denn ...</i> ' <u>Knut</u> frightened Lars since ...'	10.	NP2 / S-E / weak / coord <i>Knut ängstigte <u>Lars</u> denn ...</i> 'Knut frightened <u>Lars</u> since ...'
3.	NP1 / S-E / weak / subord <i><u>Knut</u> ängstigte Lars weil ...</i> ' <u>Knut</u> frightened Lars because ...'	11.	NP2 / S-E / weak / subord <i>Knut ängstigte <u>Lars</u> weil ...</i> 'Knut frightened <u>Lars</u> because ...'
4.	NP1 / S-E / strong / subord <i><u>Knut</u> ängstigte Lars obwohl ...</i> ' <u>Knut</u> frightened Lars although ...'	12.	NP2 / S-E / strong / subord <i>Knut ängstigte <u>Lars</u> obwohl ...</i> 'Knut frightened <u>Lars</u> although ...'
5.	NP1 / E-S / strong / coord <i><u>Knut</u> fürchtete Lars aber ...</i> ' <u>Knut</u> feared Lars but ...'	13.	NP2 / E-S / strong / coord <i>Knut fürchtete <u>Lars</u> aber ...</i> 'Knut feared <u>Lars</u> but ...'
6.	NP1 / E-S / weak / coord <i><u>Knut</u> fürchtete Lars denn ...</i> ' <u>Knut</u> feared Lars since ...'	14.	NP2 / E-S / weak / coord <i>Knut fürchtete <u>Lars</u> denn ...</i> 'Knut feared <u>Lars</u> since ...'
7.	NP1 / E-S / weak / subord <i><u>Knut</u> fürchtete Lars weil ...</i> ' <u>Knut</u> feared Lars because ...'	15.	NP2 / E-S / weak / subord <i>Knut fürchtete <u>Lars</u> weil ...</i> 'Knut feared <u>Lars</u> because ...'
8.	NP1 / E-S / strong / coord <i><u>Knut</u> fürchtete Lars obwohl ...</i> ' <u>Knut</u> feared Lars although ...'	16.	NP2 / E-S / strong / coord <i>Knut fürchtete <u>Lars</u> obwohl ...</i> 'Knut feared <u>Lars</u> although ...'

### 3.2 Results

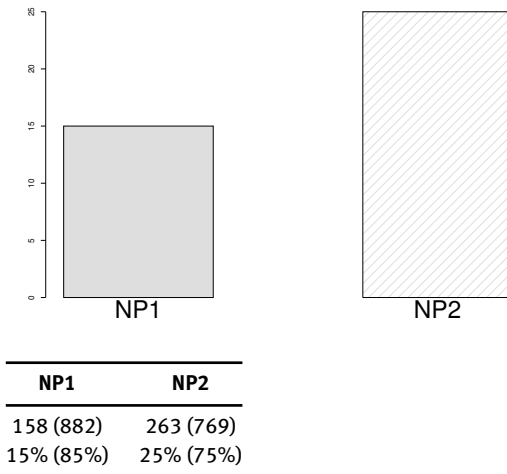
Like in Experiment 1, the sentence completion data was analysed with general linear mixed effects models using the logit link option for the binary choice of the referring expression (participants either used a pronoun or a proper name to refer to either NP1 or NP2). Fixed factors were *antecedent*, *verb causality*, *connector semantics* and *sentence structure*. *Subjects* and *items* were treated as crossed random factors in the model.

Model comparisons using the ANOVA function in R showed that including interactions for the fixed factors (antecedent, verb causality, connector semantics, sentence structure) significantly improved the fit of the model. Model comparisons also showed that adding random slopes for each of the predictors did not

significantly improve the fit of the model. Therefore, the model with interaction terms between the fixed-effects predictors was chosen for the analysis.

The analyses showed a main effect of the antecedent for Experiment 2 ( $z = -8.13$ ;  $p < .01$ ;  $SE = 0.09$ ) (see Figure 4). When the antecedent was marked to be the NP1, participants used significantly fewer noun phrases (15% noun phrases and therefore 85% pronouns) than when the NP2 was marked as the antecedent (25% noun phrases and therefore 75% pronouns). There were no other main effects in Experiment 2.

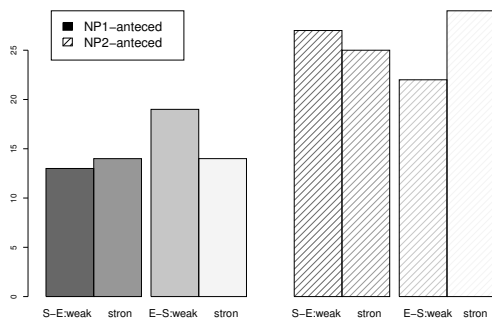
#### NP choice: effect of antecedent



**Fig. 4.** Numbers and percentages of proper name expressions in Experiment 2 (in brackets are numbers and percentages for pronoun expressions). Main effect of antecedent.

There was an interaction between *antecedent*  $\times$  *verb causality*  $\times$  *connector semantics* ( $z = 2.74$ ;  $p < .01$ ;  $SE = 0.09$ ) (see Figure 5). Simple effects analyses showed that in the E-S verb conditions, the semantics of the connector (weak or strong) affected the choice of referring expressions when the antecedent was NP1. There were significantly more expressions with a noun phrase with weak connectors (19%) than with strong connectors (14%) ( $z = 2.71$ ;  $p < .01$ ;  $SE = 0.20$ ). In addition, in the E-S verb conditions, the type of connector also affected the choice of referring expressions when the antecedent was the NP2. There were significantly more noun phrases with a strong connector type (29%) than with a weak connector type (22%) ( $z = 2.37$ ;  $p < .05$ ;  $SE = 0.14$ ).

## NP choice: antecedent × verb causality × connector type



	S-E-weak	S-E-strong	E-S-weak	E-S-strong
NP1-antecedent	33 (218) 13% (87%)	32 (195) 14% (86%)	53 (222) 19% (81%)	40 (247) 14% (86%)
NP2-antecedent	57 (153) 27% (73%)	56 (170) 25% (75%)	67 (239) 22% (78%)	83 (267) 29% (71%)

**Fig. 5.** Numbers and percentages of noun phrase expressions in Experiment 2 (in brackets are numbers and percentages for pronoun expressions). Interaction between verb causality × antecedent × connector type.

Even though there was no main effect of verb causality in Experiment 2, the E-S verbs interacted with the type of connector and the antecedent. Presented with an E-S verb, when asked to refer to the NP1, a preceding weak connector increased the number of noun phrase expressions in comparison with a preceding strong connector. In addition, when asked to refer to the NP2 (in E-S verb conditions), weak connectors had a lower number of noun phrases than strong connectors.

### 3.3 Discussion of Experiment 2

Experiment 2 investigated the participants' choice of referring expressions when describing either the first or the second noun phrase of a preceding clause. A salient noun phrase is more likely to be referred to with a pronoun, while a less salient noun will be referred to using a full name expression. Experiment 2 investigated whether semantic and structural properties of the clausal linking connector could affect the salience of the antecedent and thus the type of referring expressions.

There was a main effect of the antecedent in the second sentence completion experiment: participants used more pronouns when referring to NP1 than when

referring to NP2. There was no interaction with the S-E verb preferences. This finding is in line with previous research from Fukumura and van Gompel (2010). However, there was a three-way interaction that showed that the semantics of a connector can affect the choice of the referring expression when there was an E-S verb in German. With an E-S verb, when referring to the NP1 participants used more names when there was a weak connector (19% *weil, denn* ‘because, since’) than with a strong connector (14% *aber, obwohl* ‘but, although’). In comparison, when referring to the NP2 with E-S verbs, there were fewer proper name descriptions with a weak connector (22%) than with a strong connector (29%). Thus, Experiment 2 showed that connector types can affect the choice of referring expressions for the NP1 and the NP2. Interestingly, this effect was only found for E-S verbs and not for S-E verbs.

Thus, Experiment 2 actually replicates the findings of Fukumura and van Gompel (2010). They also reported a main antecedent effect, but no interactions with the S-E verb preferences. We also found a main effect of antecedent (same direction) and no interaction with the S-E verb. However, there was an interaction between the connector semantics on the choice of referring expressions for E-S verbs. Since they did not test E-S verbs, this is a finding that completes Fukumura and van Gompel (2010).

A possible explanation for the direction of the interaction between the NP2 and E-S verbs is: the NP2 should be more salient with E-S verbs (verb causality) and a weak connector would not change the direction of that effect. Therefore, there were more pronoun descriptions for the NP2 with E-S verbs and a weak connector than with a strong connector. A strong connector (denial of expectation) was expected to reduce the salience of the NP2 with E-S verbs. However, why did the connector semantics did not have such an effect for S-E verbs? We suggest that the verb sets preferences for NP1 or NP2. Additional information that becomes available later (at the connector) in the sentence can evoke perspectives in interaction with those verb preferences. Thus, we assume that different types of connectors interacted with the settings from an E-S verb in Experiment 2. Interestingly, the connectors did not interact with S-E verbs. This might be because the NP1 in a sentence is initially the preferred referent and this NP1 preference is additionally reinforced by the S-E verb. Thus, the NP1 preference with an S-E verb is strong and less likely to be affected by the connector type. The E-S verb on the other hand first switched the focus from NP1 to NP2 (although this effect is unobserved here) and this effect is less stable and interacts with a connector that appears later in the sentence.

## 4 General discussion

Both sentence completion experiments showed that the semantic (strong – weak) and structural (subordinate – coordinate) properties of clausal linking connectors can affect the salience of the antecedent during ambiguous pronoun resolution.

Experiment 1 showed that strong connectors (*aber, obwohl* ‘but, although’) could eliminate the IC preferences set by the verb (there was no preference for the NP1 with S-E verbs and no reduction for the NP1 with E-S verbs). In comparison, weak connectors (*weil, denn* ‘because, since’) did not affect the IC preference from the preceding clause. The structural properties of the connector also interacted with the IC preference: connectors in a coordinate clause (*aber, denn* ‘but, since’) significantly reduced the IC effect in comparison to connectors in a subordinate clause (*obwohl, weil* ‘although, because’). However, this interaction was further informed by a three-way interaction: A strong connector in a coordinate clause (*aber* ‘but’) could even reverse IC preference, while the weak connector (*denn* ‘since’) in the coordinate clause had no effect on the IC preference.

The strong effects of connector semantics on IC preference indicate that Kehler et al. (2008) underestimated the role of clausal linking in discourse. Strong clausal linking operators can signal a violation of discourse expectations and thus reduce and even reverse the IC preferences from the verb.

Experiment 2 investigated whether the connector properties could affect the choice of referring expressions and henceforth the salience of the antecedent. Fukumura and van Gompel (2010) argued that given a choice between a full name or a pronoun to describe a referent, a less descriptive pronoun would be preferred to describe the item that is more salient. The more descriptive full name would be used to describe an item that is less salient in the discourse. Experiment 2 has found a pronoun preference when describing the NP1 and no interaction between connector strength and S-E verb preferences, which replicates the findings of Fukumura and van Gompel (2010). The finding that the connector type interacted with E-S verbs to modulate this NP1 preference completes the findings of Fukumura and van Gompel (2010). A strong connector decreased the full name descriptions for E-S verbs when referring to NP1, while it increased the full name descriptions for E-S verbs when referring to NP2. This connector effect was found only for E-S verbs and we assume that noun phrase preferences are more flexible when set by E-S verbs than when they are set by S-E verbs. An E-S verb should make the reference to the NP2 easier and thus there should be more pronoun references to the NP2. This effect was reduced by the strong connector: a strong connector in combination with an E-S verb made the NP1 more salient and the NP2 less salient.

As a conclusion: this paper presented two experiments that showed how clausal linking can change the focus between noun phrases for reference resolution. We argued that the salience of an item in ambiguous pronoun resolution is affected by the properties (semantic and structural information) of a connector that links clauses together. Experiment 1 showed that strong connectors cancelled the preferences for an antecedent which was initially set by an IC verb. The initial preference could even be reversed when the strong connector was presented in a coordinate clause. The extent of the effect from strong clausal linking operators was underestimated by Kehler et al. (2008). Experiment 2 could replicate the findings of Fukumura and van Gompel (2010): pronouns are more likely to be used to refer to the NP1 than the NP2 and there is no effect of connector properties on S-E verbs. However, the semantics of the connector affected the pronoun preferences set by E-S verbs. The finding that strong connectors could decrease the salience of the NP2 with E-S verbs completes the results from Fukumura and van Gompel (2010).

Thus, the properties of the connector that links clauses together seem to have as much an impact on ambiguous anaphor resolution as verb causality and should not be underestimated. We have shown that they can reverse the verb causality effect in Experiment 1 and they affected the salience of noun phrases in interaction with E-S verbs in Experiment 2 (where verb causality was not a main effect). Connector properties thus affect the reference to an antecedent (Experiment 1) and the choice of referring expressions for an antecedent (Experiment 2). Both, the reference and form of expression reflect the salience of the referring noun in discourse. Establishing coherence in a sentence between an anaphor and its antecedent thus seems to be built by the discourse in interaction with the clausal linking properties.

These results may have interesting implications for the current discussion on the proper discourse segmentation in processing. Given there is an IC verb in the discourse we can take the original verb causality bias as an indicator for the size of a discourse unit. If an IC verb sets a certain preference for a specific antecedent (NP1 or NP2), we propose that the discourse unit ends when that preference changes (either from NP1 to NP2 or from NP2 or NP1).

Thus, in a complex sentence with an IC verb in the first clause a discourse unit includes both, the first clause and a combined verb-final subordinate or verb-second coordinate clause when (a) the subordinate clause is introduced by *weil* 'because' (weak) or *obwohl* 'although' (strong) or when (b) the coordinate clause is headed by a weak connector such as *denn* 'since'. On the other hand, if the combined coordinate clause is introduced by a strong connector such as *aber* 'but', which reverses the original IC bias, two discourse units must be stipulated. Thus,

in these cases a discourse unit is bound to the range of the IC preference bias set by the verb.

Therefore, the distinction between weak and strong connectors does not affect the discourse unit in case of a subordinate clause. However, this distinction has an effect in case of a coordinate clause: a strong connector in a coordinate clause may mark the beginning of a new discourse unit.

We conclude that the sentence structure alone does not signal discourse segmentation; but in interaction with a connector type it may indicate discourse structuring. In particular, it is not the case that every coordinate clause introduces a new discourse segment. On the basis of the experimental findings presented here, we suggest that a new discourse unit starts only when a strong connector is realised at the beginning of a coordinate clause. Whether this proposal can be generalised to other types of discourse, will be subject for further experimental investigations.

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