

**Negation cancels discourse-level processing differences: Evidence from reading times in
concession and result relations**

Abstract

Seminal studies on negation revealed that negative sentences are difficult to process, as they require an extra mental step. Similarly, at the discourse level, concession has been repeatedly shown to be more complex than other relations such as result because it implies the denial of an inference. The affinity between negation and concession prompted the present study to test whether overt verb polarity would affect the processing of upcoming discourse relations. In particular, it investigated whether negation can act as a cue to help process concessive relations. Results from four self-paced reading experiments indeed show a robust facilitation effect of negation on concession that cancels the baseline difference between concessive and result relations, thus nuancing existing context-blind categorizations of concession as a highly complex relation. This study furthers our understanding of how various types of cues interact in discourse processing and switches the focus from “what makes negation easier to process” to “what is made easier thanks to negation”.

Keywords: negation, concession, result, discourse processing, self-paced reading

Introduction

One of the most basic functions of language is to describe and assert (Jakobson, 1985[1976]). The default encoding for assertions is a positive sentence which states some proposition as being true (e.g. *My cat's name is Wallace*). Negative sentences, on the other hand, are primarily used to make denials (e.g. *Is your cat named Gromit? No, my cat's name is not Gromit*), in which contexts they are processed without much difficulty (Johnson-Laird & Tridgell, 1972). In general, however, processing times and neurological responses are enhanced in negative sentences compared to their positive counterparts (e.g. Wason, 1959; Kaup, Lüdtke, & Zwaan, 2006). Several authors have proposed to account for this difference between negative and positive polarity (e.g. the two-step account of negation processing, Kaup et al., 2006) and to identify conditions under which this difference is reduced, such as pragmatic licensing (Nieuwland & Kuperberg, 2008) or contextual prominence (Tian, Ferguson, & Breheny, 2016). By contrast, what is much less documented is how negation itself can be used as a predictive cue to process some contexts more easily than others. This study takes such an approach to negation and switches the focus from “what makes negation easier to process” to “what is made easier thanks to negation”. In particular, it investigates the effect of negation in the context of discourse relations.

In this paper, we explore the effect of negative vs. positive polarity on the processing of two discourse relations, namely result (1) and concession (2).

(1) My sister is an excellent cook. As a result, she made a delicious cake for dessert.

(2) My sister is an excellent cook. However, she made a disgusting cake for dessert.

In result relations like (1), the link between the two clauses is logical and expected, while in concession, the second segment is unexpected and denies a causal inference from the first segment: if someone made a disgusting cake, then they are probably *not* a good cook.

This denial of expectation is made explicit when the first segment of the concession is negative, as in (3), although result relations are also possible in negative polarity, as in (4).

(3) My sister doesn't know how to cook. However, she made a delicious cake for dessert.

(4) My sister doesn't know how to cook. As a result, she made a disgusting cake for dessert.

Causal relations such as result have repeatedly been shown to be processed faster than concessive relations (Townsend, 1983; Morera, Leon, Escudero, & de Vega, 2017; Xu, Chen, Panther, & Wu, 2018), a finding attributed to the negative component in concession (Köning & Siemund, 2000), which slows down the representation of that relation. The affinity between concession and negation, already observed in production (Crible, *in press*), can be expected to speed up the processing of concession and reduce the difference with result relations.

While we know a lot about the effect and time-course of negation processing at the sentence level, its role at the discourse level remains to be investigated (but see Lyu, Tu, & Lin, 2019). The interaction between verb polarity and discourse relations will further our understanding of the role of segment-internal cues (i.e. other than connectives), which have mainly been studied in production (e.g. Das & Taboada, 2018) whereas their role in processing has attracted interest only recently (Grisot & Blochowiak, 2019; Crible & Pickering, 2020; Schwab & Liu, 2020). The present study thus contributes to this growing line of research and adopts a new perspective towards negation as a concessive facilitator.

Studies on causal vs. concessive relations and accounts of negation processing are reviewed in the next sections. I then report on four self-paced reading experiments that measure the effect of positive vs. negative polarity across discourse relations under various conditions (with and without delay, with an extra spill-over region, with and without explicit

connectives). The final sections discuss the findings and potential limitations of the study (e.g. difference between offline and online measures) and provide some conclusions on the processing of negation in general and its status as a cue for concessive relations in particular.

The processing of negation

Negation has for a long time been described as a secondary, “marked”, non-standard form that is subordinated to or dependent on a corresponding positive statement (Wason, 1959). Kaup et al. (2006, p. 1033) developed a two-step account of negation processing, according to which “understanding a negated sentence requires representing the negated state of affairs”: in their view, “the door is not open” is first represented as an open door, then this representation is mentally rejected before the actual state of affairs (a closed door) can be accessed. In a picture-naming task with a between-subject delay manipulation, the authors found that, after a long delay, comprehenders of a negative sentence switch their attention from the negated to the actual state of affairs (e.g. from “not-open door” to “closed door”), which supports this two-step account of negation.

However, many studies have also found conditions in which negative sentences are processed very fast with no additional cost: when they are presented as plausible denials (Johnson-Laird & Tridgell, 1972), when they are pragmatically licensed (Nieuwland & Kuperberg, 2008), when the negated proposition was explicitly mentioned in the context (Schindele, Lüdtke, & Kaup, 2008), when the positive Question Under Discussion was prominent in the context (Tian et al., 2016). Evidence for these facilitating effects on negation converge from neurological and behavioral data alike. Therefore, it seems that the processing of negation is highly depending on the previous context and suggests that only “out-of-the-blue” (i.e. discourse-initial) negative sentences are truly more costly than positive

ones. As Tian and Breheny (2019, no page) conclude, “negation has stricter context requirements than its positive counterpart.”

All these studies manipulate the context before the negation. By contrast, an area that has been much less studied is the effect of negation itself on the processing of subsequent words, that is, whether negative polarity generates predictions that speed up the processing of upcoming material. This is the object of Staab’s (2007) set of ERP experiments where she found that inconsistent endings of negative sentences (e.g. *Joe wanted something salty so he bought cookies*) are more expected than those in affirmative sentences. Staab concludes that “for negation effects to be detectable, the plausibility of a continuation should somehow depend on the presence or absence of negation” (Staab, 2007, p. 206). While she tested this on the lexical level (i.e. within a single sentence), the present study turns to discourse processing to replicate these findings on result and concessive relations.

Discourse processing: result and concessive relations

Discourse relations are mental representations of the connection between two propositions (Mann & Thompson, 1988). They include result, cause, contrast, concession, condition and many more. Relations are traditionally considered to be explicit when they are expressed by connectives (e.g. *so, because, but, however*, etc.), although other features of the segments can also contribute to their construal, such as focus markers in contrast (Carlson, 2014), complementizers in consequence (Rohde, Tyler, & Carlson, 2017) or prosody (Didirková, Crible, & Simon, 2019). Discourse relations vary in their meaning and encoding, but also in their processing complexity (Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985; Sanders & Noordman, 2000). In particular, concession is quite complex to process as it involves the denial of an expectation. An early study by Townsend (1983) indeed showed that concessives are processed more slowly than causals and that recall is

worse for concessives. Evidence from acquisition also suggests that concessive connectives are acquired later than other connectives (Bloom, Lahey, Hood, Lifter, & Fiess, 1980).

Several studies have looked at concession in relation to congruence, building on the notion that a concessive relation sets up an “alternative world model” where incongruencies are less surprising and therefore processed more easily than in other relations such as cause (Xiang & Kuperberg, 2015). Xu, Chen, Panther and Wu (2018) have confirmed this in an eye-tracking study and showed that concession is more costly to process than cause overall and that there is no difference between congruent and incongruent conditions in concession, due to a ceiling effect, that is, concession being already quite difficult to process (cf. Lyu, Tu, & Lin, 2019).

Concession is sometimes described as a “negative causal” relation (Köning & Siemund, 2000; Sanders, Spooren & Noordman, 1992) since the assumption or conclusion of one of its arguments is denied. In fact, this denial-of-expectation is often explicit in production: corpus studies have shown that negation is very frequent in concession relations, although it also occurs in many other relations (Asr & Demberg, 2015; Crible, in press). Beyond production, the cognitive cost of concession has also been associated with the processing of negation. Köhne and Demberg (2013) explicitly relate concession to negation in an eye-tracking study using the visual world paradigm and observe that concessive connectives lead to a search for alternatives, with later looks to the target, much like the effect of negation (cf. Kaup et al., 2006). Morera et al. (2017) also explored the links between concession and negation, but from the viewpoint of emotional valence (e.g. “pass” vs. “fail” an exam) rather than overt verb polarity (“not pass”). In a continuation selection task, they found that negative valence was cognitively more costly in causal items, whereas the opposite was true in concession (positive valence more costly), suggesting a bias for positive-causal and negative-concession. Negation and concession were also combined in Lyu et al.’s (2019)

reading study, where polarity is mainly used to manipulate the plausibility of the sentence: the negative polarity of the verb in the second clause creates a plausible scenario following an initial concessive connective (Example 5) but an implausible one after a causal connective (Example 6). Positive polarity was also included with both relations, with the reverse effect in plausibility (causal-plausible, concessive-implausible).

(5) Although Ahui has a talent for language, he doesn't like learning English. Everybody knows it.

(6) Because Ahui has a talent for language, he doesn't like learning English. Everybody knows it.

With these materials, the authors find a larger plausibility effect in concessives than causals and conclude that negation is expected and even preferred in concession. However, they did not include plausible conditions with negative polarity in causality and positive polarity in concession, so that it is hard to assess the effect of negation independently from plausibility in their experiments. Like most studies reviewed above, Lyu et al.'s (2019) study aimed at uncovering contexts in which negation is easier to process, rather than testing the effect of negation on the processing of upcoming linguistic content.

Negation as a concessive facilitator

The present study investigates the role of negation as a potential cue to better integrate an upcoming concessive relation. Previous literature showed that both negation and concession are cognitively more costly than their positive equivalents (affirmation and causality, respectively), especially when negation is presented without an appropriate prior context. Whether negation affects the processing of subsequent material has so far only been tested at the sentence level. It is therefore an entirely open question whether negation

generates a concessive expectation across sentences. Such expectations would show that negation can act as a discourse cue, i.e. a signal that helps comprehenders predict and infer a specific type of discourse relation, like parallelism for contrast (Crible & Pickering, 2020) or implicit causality verbs for causal relations (Rohde & Horton, 2014). In production, negation is not restricted to concession, which doesn't make it a very strong concessive signal (Crible, in press). In fact, Asr an Demberg (2015) showed that it is much more associated with "chosen alternative" relations (cf. Webber, 2013), where it rarely combines with an explicit connective (i.e. it can express that relation on its own), while, in concession, negation is less frequently the unique cue but often co-occurs with connectives such as *but*. However, these production findings might not exactly reflect online cognitive processes. The conceptual link between negation and concession, as well as prior findings on a negative preference in concession (Lyu et al., 2019) instead suggest that the baseline difference between result and concessive relations will be reduced in negative polarity. In particular, while result relations are expected to be read faster in positive than negative polarity (cf. Morera et al., 2017), the effect of polarity should be smaller or even reversed in concession, with faster reading times after a negative first clause than a positive one.

In sum, this study intends to bridge the gap between sentence-level processing of polarity and discourse-level processing of result vs. concession. It switches the focus from "negation-friendly" contexts to the effect of negation as a concessive facilitator. In doing so, the study furthers our understanding of negation in general and contributes to a more comprehensive approach to discourse relations by measuring the effect of non-connective cues (here, negation) on their interpretation.

Experiment 1

Predictions

The first experiment addresses the main research question of this study and tests whether polarity modulates the processing of discourse relations. It compares result and concessive relations when the verb of the first clause is either in positive or negative polarity. In particular, I expect a baseline main effect of Relation such that result relations will be read faster overall. In addition, I further expect a main effect of Polarity, with faster reading times for positive than negative conditions. Finally, and crucially, negation is expected to speed up the processing of concession, with faster reading times for negative concession compared to positive concession.

Participants

For this experiment, 80 native participants were recruited on the web-based crowdsourcing platform Prolific (65% female, 34yo on average, aged 18-82yo) and were remunerated £1.3 for their contribution.

Materials

Materials include 40 pairs of sentences that represent either a result or a concessive relation between the connected clauses. Result is defined here as a relation between two clauses where the second clause brings about the logical effect of the situation of the first clause. Concession, in turn, corresponds to cases where the situation in the second clause is unexpected based on a causal inference from the first clause. These relations were manipulated by changing one word from the second segment, such as “confident” (Examples 7 and 8) vs. “anxious” (Examples 9 and 10).

- (7) The students had an upcoming exam. They all knew their coursework well and they were confident about their performance. [positive result]

- (8) The students had an upcoming exam. They didn't know their coursework and they were confident about their performance. [negative concession]
- (9) The students had an upcoming exam. They all knew their coursework well and they were anxious about their performance. [positive concession]
- (10) The students had an upcoming exam. They didn't know their coursework and they were anxious about their performance. [negative result]

The experimental item above expresses a result relation in (7) and (10) and a concessive relation in (8) and (9): students who know their coursework can logically feel confident about an exam, whereas those who have not studied may feel anxious. Polarity is manipulated on the verb of the first clause of the relation (“knew” vs. “didn't know”). This differs from most previous studies where negation only occurs after the critical manipulation, not before. As a result, the relation is not made explicit in the first clause through an initial connective like *although p, q* but only at the critical word (i.e. the word that makes the result or concessive relation clear, e.g. “confident” vs. “anxious”) in the second clause.

All items start with a neutral sentence that sets up the discourse context (“The students had an upcoming exam”). Then, the first and second clauses of all relations are connected by *and*, which can occur both in result and concession: Crible (2020) reports a similar frequency of *and* in concession (78 cases) and result relations (50 cases), which corresponds to about 3% each of the total uses of *and* in her corpus (see also Prasad, Miltsakaki, Dinesh, Lee, & Joseph, 2008). Kitis (2000) and Blakemore and Carston (1999) discuss concessive uses of *and* at length from more theoretical perspectives with examples such as *His friends are waiting for him and he is on the phone* or *Paul is a linguist and he can't spell*. Although *and* is not the most frequent connective in concession or result, it was chosen here to avoid implausible conditions while maintaining a fully counter-balanced design: using a more specific connective like *so* or *but* would have added an extra degree of

variation and would have made some conditions implausible (e.g. *They all knew their coursework well so they were anxious about their performance). The plausibility effect has already been extensively studied before (Xu et al., 2018; Lyu et al., 2019) so that it was decided to remove this additional variable. The use of *and* was also chosen in order to work on so-called forward causality (i.e. result relations typically expressed by *so* or, in some cases, *and*) rather than backward causality typically expressed by *because*, since most previous studies always focus on the latter (but see Köhne & Demberg, 2013, on *daher* ‘therefore’ vs. *dennoch* ‘nevertheless’).

The four conditions of the 40 items are fully counter-balanced and no participant saw the same item twice. In addition to the stimuli, 60 fillers were created, all following the same pattern, that is, a first sentence and two more clauses conjoined by *and*. Among the fillers, 30 sentences are neutral descriptions, as in (11), and another 30 are nonsensical, as in (12). The inclusion of nonsensical fillers is motivated by the coherence rating task that was presented after each item (see Procedure below). Within descriptive and nonsensical fillers, half were in the negative polarity, the other half were positive.

(11) Alfred just became a grandfather. His son had a baby girl and she is very precious to him already.

(12) Kelly bought a new sofa set. It is not afraid of the dark and she can only sit with her arms crossed.

The length of the first clause is controlled across conditions whenever possible, however in some materials the negative condition is slightly longer. It is unlikely that such differences would be carried on to the critical segments of the second clause (final sentence). In addition, length would not act as a confound for the hypothesis regarding the interaction between negation and concession, as the negative condition (longer in words) is expected to

be read faster in concession than the positive condition. Other than the critical word and the polarity manipulation, the rest of the items is the same across conditions. The average length for all items is 63 characters ($SD = 8$) or 11 words ($SD = 2$; 11.4 for negative items vs. 11.08 for positive items).

Procedure

All items were split in five segments, represented by forward slashes “//” in (13) below. The first sentence appeared as a whole, followed by the first clause of the relation. The second clause of the relation was divided in three segments: the connective region, which also includes the grammatical subject; the critical region, which ends after the disambiguating word; the spill-over region, which is the same across conditions. For filler items, the segments of the final clause were placed at similar positions, after every two or three words.

- (13) The students had an upcoming exam. [Context] // They all knew their coursework well [Clause 1] // and they [Segment 1] // were confident [Segment 2] // about their performance. [Segment 3]

The task used a self-paced reading paradigm. Participants first saw crosses at the centre of the screen as a fixation point, and had to press the space bar on the keyboard in order to show the first segment. Pressing space would then remove the first segment and show the next one instead, until all segments were read. At this point, a rating scale appeared on the screen, ranging from 1 (“the sentence makes no sense – illogical, nonsensical”) to 7 (“the sentence makes perfect sense – logical, expected”). Participants were instructed to “indicate on the scale if the third sentence (after “and”) makes sense and follows logically or not from the circumstances of the previous sentences.” Once they validated their rating, three crosses appeared at the center of the screen, and participants had to press the space bar again

to show the next sentence. The aims of the rating task are to ensure active processing of the sentences by the participants and to gather offline data for hypothesis testing. More specifically, ratings are expected to be lowest for nonsensical fillers, highest for result items and lower for concessive items, with the same interaction effect hypothesized for reading times (negative concession rated higher than positive concession, and *vice versa* for result relations).

There was no time constraint on this task. The order of presentation was individually randomized. The experiment was divided in two parts, separated by a mandatory 10-second break. Participants were also prompted to pause for as long as they wanted at two more points during the task. The experiment was designed on Psychopy (Peirce, Gray, Simpson, MacAskill, Höchenberger, Sogo, et al., 2019) and run online. Participants took about 18 minutes to complete the study on average.

Data analysis

For all experiments in this study, we computed linear mixed effects regression models with the *lmer* function of the {lme4} package of R, and used the *anova* function for model selection (Baayen, Davidson, & Bates, 2008). Maximal random structures were always included in all models unless models failed to converge, in which case only the maximally converging version is reported. We measured post-hoc comparisons with the *ghlt* function of the {multcomp} package (Hothorn, Bretz, & Westfall, 2008), with Tukey pair-wise comparisons applying Bonferonni correction. Predictors were dummy coded (-0.5 and +0.5) and mean centered in all analyses. The pre-registration form, along with ethics approval, complete materials and analysis scripts for all four experiments, are available at https://osf.io/hdj4x/?view_only=5d2708b6dbab47b6b2256c0f4d905481.

Sense rating task.

Average scores for the sense rating task are presented in Table 1. Differences between relations are as expected, with very high scores for neutral fillers and result, intermediate scores for concession and very low scores for non-sensical fillers.

Table 1. Average sense ratings by relation and polarity (Experiment 1)

	result	concession	neutral	nonsense	Total
positive	6.50	3.63	6.50	1.76	4.60
negative	6.23	3.84	5.94	1.40	4.35
Total	6.36	3.73	6.22	1.58	4.47

Zooming in on the critical trials (result and concession), the model with random intercepts and random slope for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 85.39$, $\Delta df = 1$, $p < .001$). Adding Polarity to this model further improved it ($\Delta\chi^2 = 27.29$, $\Delta df = 2$, $p < .001$). The final model (Rating $\sim$ Relation * Polarity + (1 + Relation | Participant) + (1 + Relation | Item)) returned a main effect of Relation, with higher scores for result than for concession relations ($\beta = -1.31$, $SE = 0.08$, $t = -15.46$, $p < .001$). There is no main effect of Polarity ($\beta = -0.01$, $SE = 0.02$, $t = -0.58$, $p = .56$). However, the interaction between Relation and Polarity is significant ($\beta = 0.12$, $SE = 0.02$, $t = 5.2$, $p < .001$). All differences are statistically significant in this interaction. It confirms the hypotheses regarding a preference for positive polarity in result and negation in concession.

Self-paced reading task.

We first removed extreme values above 5,000ms ($n=62$) or under 50ms ($n=3$). We then defined the cut-off value at 2.5 standard deviations under or above the mean by participant. These outliers were substituted by the corresponding cut-off value ($n = 438$; 3.5% of the data). Reading times are reported for the connective, critical and spill-over regions,

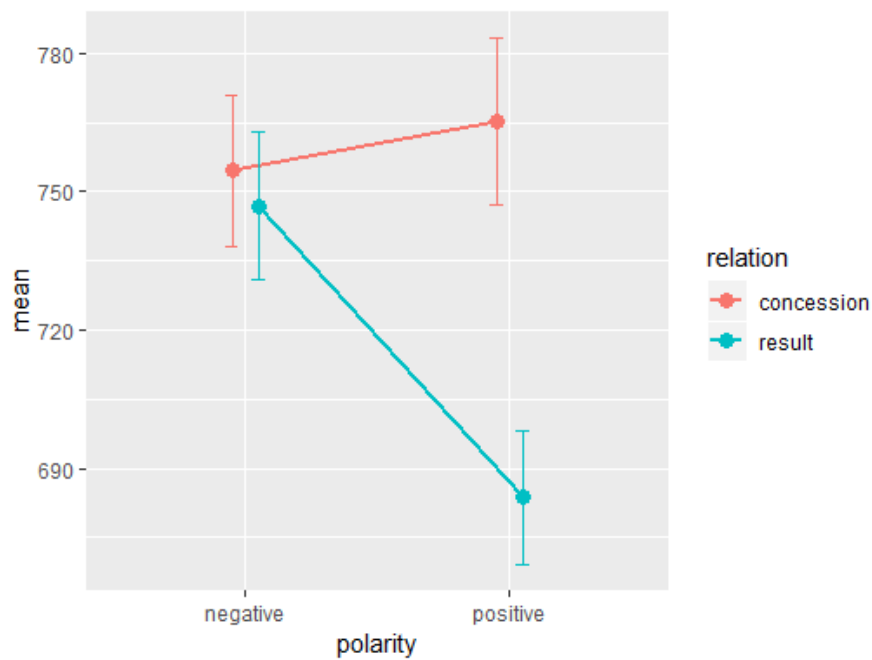
since the first clause was presented as a whole and was not exactly comparable across positive and negative conditions.

Segment 1. This region corresponds to the connective and the subject of the second clause of the relation. As a reminder, the connective is always *and* and the region does not include specific cues towards one relation or the other (no critical word in this region). Thus, there should be no effect of relation on Segment 1. The model with random intercepts and random slopes for Polarity by item and by participant was significantly improved by adding Polarity as predictor ($\Delta\chi^2 = 20.96$, $\Delta df = 1$, $p < .001$). Adding Relation to this model did not further improve it ($\Delta\chi^2 = 1.72$, $\Delta df = 2$, $p = .42$). The final model ($RT \sim \text{Polarity} + (1 + \text{Polarity} | \text{Participant}) + (1 + \text{Polarity} | \text{Item})$) returned a marginally significant effect of Polarity, with slightly faster reading times after positive ($M = 629\text{ms}$; $SD = 285$) than after negative sentences ($M = 648\text{ms}$; $SD = 323$) ($\beta = 9.43$, $SE = 5.02$, $t = 1.88$, $p = .07$).

Segment 2. This region corresponds to the verb phrase and stops after the critical (disambiguating) word. At this point, the relation (result vs. concession) becomes interpretable. The model with random intercepts and slopes for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 8.55$, $\Delta df = 1$, $p < .01$). Adding Polarity to this model further improved it ($\Delta\chi^2 = 11.82$, $\Delta df = 2$, $p < .01$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 + \text{Relation} | \text{Participant}) + (1 + \text{Relation} | \text{Item})$) returned a main effect of Relation, with faster reading times after result ($M = 715\text{ms}$; $SD = 429$) than after concession relations ($M = 760\text{ms}$; $SD = 480$) ($\beta = 26.47$, $SE = 8.7$, $t = 3.04$, $p < .01$). It also returned a main effect of Polarity, with faster reading times after positive ($M = 724\text{ms}$; $SD = 459$) than after negative sentences ($M = 750\text{ms}$; $SD = 451$) ($\beta = 13.03$, $SE = 6.02$, $t = 2.16$, $p < .05$). Finally, the interaction between Relation and Polarity is also significant ($\beta = -16$, $SE = 6.02$, $t = -2.66$, $p < .01$). There were significant differences between relations in the positive conditions but not in the negative ones, with faster reading times in

positive result relations ($M = 683\text{ms}$; $SD = 405$) than in positive concession ($M = 765\text{ms}$; $SD = 506$; $p < .01$). There was also a difference between polarities within result relations but not within concession, as can be seen in Figure 1 (error bars in this and all following figures are determined by adding or removing the standard error to the mean of the corresponding value).

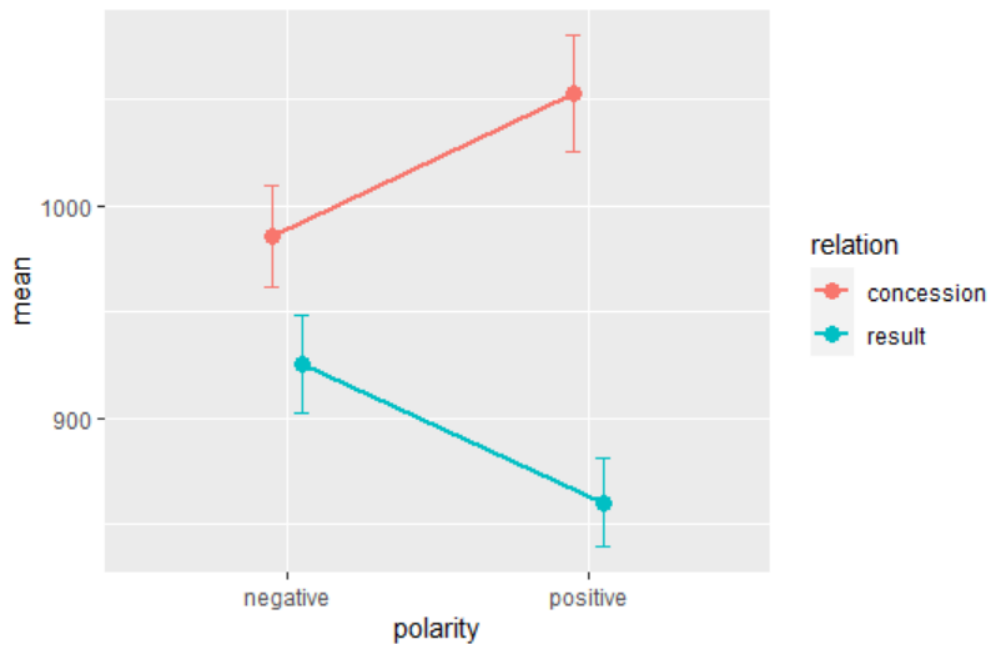
Figure 1. Mean reading times by condition on Segment 2 (Experiment 1)



Segment 3. This is the spill-over region; it is the same across conditions and includes non-disambiguating complements. The model with random intercepts and random slope for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 20.35$, $\Delta df = 1$, $p < .001$). It was further improved by adding Polarity ($\Delta\chi^2 = 9.89$, $\Delta df = 2$, $p < .01$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 + \text{Relation} | \text{Participant}) + (1 + \text{Relation} | \text{Item})$) returns a main effect of Relation, with faster reading times after result ($M = 893\text{ms}$; $SD = 622$) than after concession relations ($M = 1,019\text{ms}$; $SD = 714$) ($\beta = 70.78$, $SE = 14.23$, $t = 4.98$, $p < .001$). There is no main effect of Polarity. However, the interaction between Relation and Polarity is significant ($\beta = -29.92$, $SE = 9.52$, $t = -3.14$, $p < .01$). More specifically, there were significant differences between relations in the positive

conditions, not in the negative ones (as in the critical segment). There are no longer differences between polarities within each relation. The effects on the spill-over region can be seen in Figure 2.

Figure 2. Mean reading times by condition on Segment 3 (Experiment 1)



Discussion

This first self-paced reading experiment confirmed the hypotheses regarding the processing differences between result and concession, positive and negative polarity, and the facilitating effect of negation on concessive relations. The results of the sense rating task indicate that, when asked to explicitly judge how (il)logical and (un)expected a sentence is based on prior context, participants give higher scores to result than concession, with a modulating effect of polarity: negation decreases the scores for result items but increases those for concessive items. Offline data therefore suggests that the preferred polarity for result is positive and that for concession is negative (cf. Morera et al., 2017).

This is confirmed by the online reading times, with a significant interaction between Relation and Polarity on the critical and spill-over regions, such that the difference between

result and concession is no longer significant when both relations are presented with a negative first clause. This modulating effect of polarity is substantial, considering the large and stable baseline difference between relations overall. Positive result remains by far the fastest condition to read, which reflects the offline sense ratings.

The study also shows an effect of negation on reading times of the connective region, which indicates that the cost of negation is immediate. This cost is reduced for concession on the critical segment, and disappears entirely on the spill-over region, which no longer shows a main effect of polarity (the interaction remains significant, however).

Although negative concession is not read faster than positive concession by the participants, we can see that, on the spill-over region, there is a visible yet non-significant 50ms difference between polarities in the expected direction (cf. Figure 2 above). This pattern of result reproduces exactly that of Lyu's (2019) self-paced reading study, where she found no difference between negative and positive expressions (e.g. *not save* vs. *delete*) on the verb after a concessive connective, and only a marginal preference for the negative form at the end of the sentence. Four possibilities can explain this lack of significance. Firstly, the initial segment of a concessive relation is usually processed in a superficial form (Townsend & Bever, 1978, 1982), so that the negative verb of the first clause might not have enough of a lasting effect to fully reverse the processing pattern of the following clause. Secondly, individual differences could prevent this difference from reaching significance, and the hypothesis could only apply to some items and/or some participants but fail to generalize. Such methodological shortcomings will be further addressed in the General discussion. Thirdly, there could be a ceiling effect of difficulty in the processing of concession, especially with the ambiguous connective *and*, that blocks any further difference between polarities. This would echo Xu et al.'s (2018) finding of a ceiling effect for plausibility in concession. Fourthly, the expected effect (negative concession read faster) could emerge in a

further spill-over region, as suggested by the fact that the cost of negation progressively disappears over time. The possible ceiling effect will be addressed in Experiment 4, where more explicit connectives than *and* are used. Experiments 2 and 3 further investigate the time-course of negation processing and its effect on concession to see whether negative concession does become faster to read after a while.

Experiment 2

Predictions

The second experiment introduces a 1,500ms delay before the second clause of the discourse relation. In doing so, the aim is to test whether the difficulty associated to negation is reduced compared to Experiment 1, which could result in a larger difference between positive and negative concession. In addition to the baseline effects of Relation and Polarity, already observed in Experiment 1, I therefore expect that negative concession will be read significantly faster than positive concession, once the baseline difficulty of this polarity has been removed by the added delay. Negative result is still expected to be read more slowly than positive result, although this difference will be further reduced and tend to disappear over time.

Participants

For this experiment, 80 new native participants were recruited on Prolific (56% female, 34yo on average, aged 18-67yo) and were remunerated £1.75 for their contribution.

Materials and procedure

The items and fillers were the same as in Experiment 1, except that a 1,500ms delay was added before the connective region appeared on the screen, as in Kaup et al. (2006). The

rest of the procedure is the same. Participants took about 22 minutes to complete the study on average.

Results

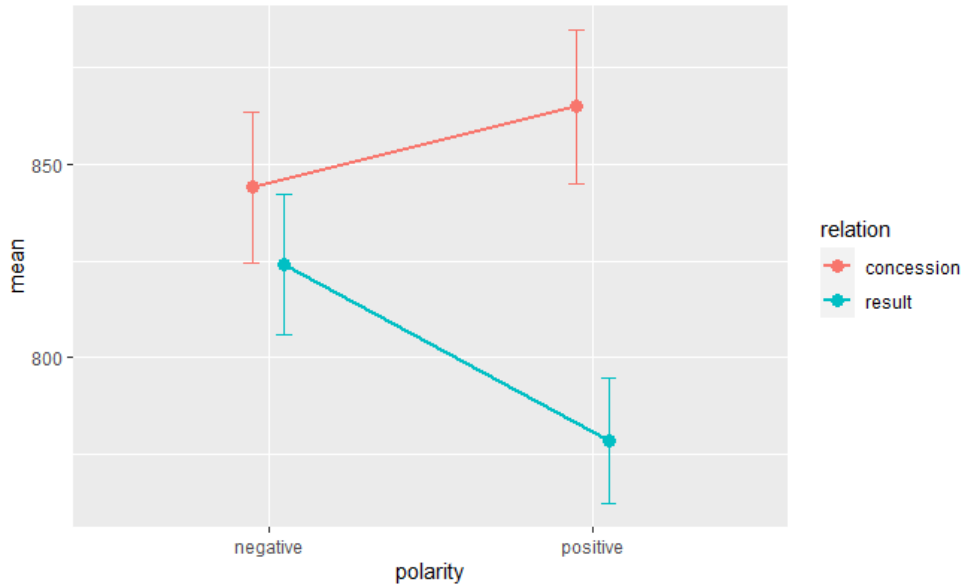
Extreme values were removed following the same procedure: any data point above 5,000ms ($n=66$) or under 50ms ($n=44$) was deleted. The cut-off value for outliers was then defined at 2.5 standard deviations under or above the mean by participant ($n=413$; 3.3% of the data). I will only report reading times for the three segments following the delay manipulation.

Segment 1. As a reminder, this region corresponds to the connective *and* and the subject of the second clause of the relation. The model with random intercepts and random slopes for Polarity by participant and by item was not significantly improved by adding either Polarity ($\Delta\chi^2 = .01$, $\Delta df = 1$, $p = .97$) or Relation as predictor ($\Delta\chi^2 = .15$, $\Delta df = 1$, $p = .7$). The mean reading time for this segment is about 620ms for all polarities and relations.

Segment 2. This region corresponds to the verb phrase and stops after the critical (disambiguating) word. The model with random intercepts and random slopes for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 9.12$, $\Delta df = 1$, $p < .01$). Adding Polarity to this model further improved it ($\Delta\chi^2 = 6.62$, $\Delta df = 2$, $p < .05$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 + \text{Relation} | \text{Participant}) + (1 + \text{Relation} | \text{Item})$) returned a main effect of Relation, with faster reading times after result ($M = 801\text{ms}$; $SD = 429$) than after concession relations ($M = 854\text{ms}$; $SD = 480$) ($\beta = 26.15$, $SE = 8.22$, $t = 3.18$, $p < .01$). There was no main effect of Polarity ($\beta = 7.31$, $SE = 7.05$, $t = 1.04$, $p = .3$). However, the interaction between Relation and Polarity was significant ($\beta = -16.62$, $SE = 7.05$, $t = -2.36$, $p < .05$). The only significant difference is that between positive result ($M =$

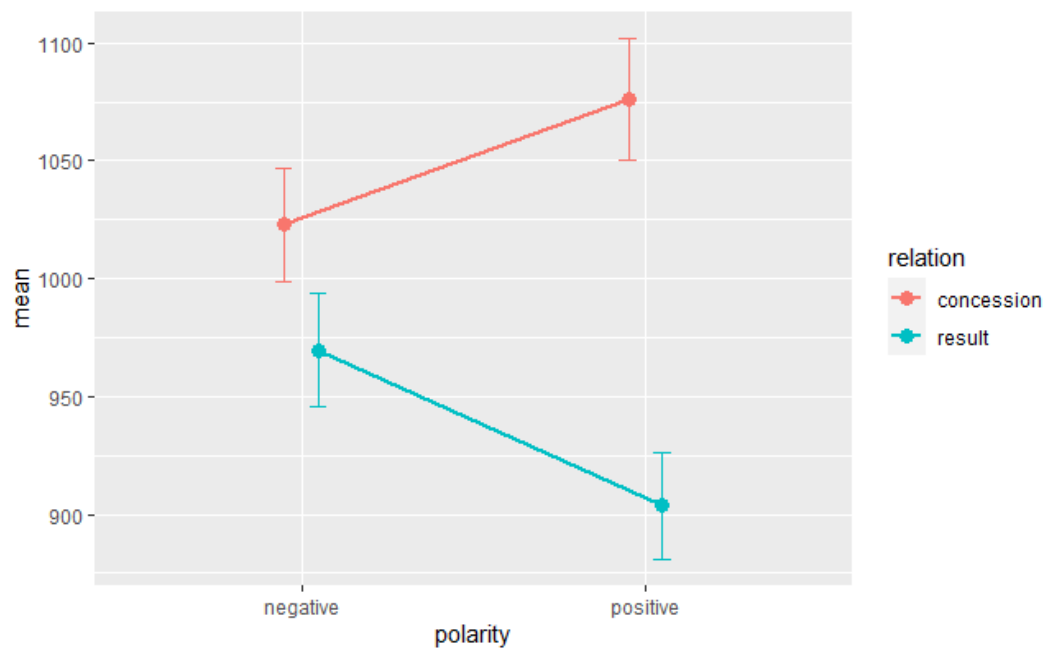
778ms; $SD = 448$) and positive concession ($M = 865\text{ms}$; $SD = 552$; $p < .01$), as can be seen on Figure 3.

Figure 3. Mean reading times by condition on Segment 2 (Experiment 2)



Segment 3. This is the spill-over region. The model with random intercepts and random slopes for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 17.44$, $\Delta df = 1$, $p < .001$). It was further improved by adding Polarity ($\Delta\chi^2 = 9.29$, $\Delta df = 2$, $p < .01$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 + \text{Relation} | \text{Participant}) + (1 + \text{Relation} | \text{Item})$) returns a main effect of Relation, with faster reading times after result ($M = 937\text{ms}$; $SD = 654$) than after concession relations ($M = 1049\text{ms}$; $SD = 679$) ($\beta = 84.89$, $SE = 12.12$, $t = 4.53$, $p < .001$). There was no main effect of Polarity ($\beta = 4.57$, $SE = 9.5$, $t = 0.48$, $p = .63$). However, the interaction between Relation and Polarity was significant ($\beta = -28.63$, $SE = 9.5$, $t = -3.01$, $p < .01$). More specifically, differences between relations are only significant in the positive polarity. Differences between polarities within a given a relation are not significant, as can be seen on Figure 4.

Figure 4. Mean reading times by condition on Segment 3 (Experiment 2)



Discussion

In this experiment where a 1,500ms delay was introduced before the second clause of the relation, the results show that the difference between positive and negative result is not significant on Segments 2 or 3. This differs from the pattern in Experiment 1, where we found that positive result was read faster than negative result in the critical region. This could indicate that, as predicted, the delay has reduced the processing cost of negation. However, there was still no significant difference between polarities for the concessive items, against the hypothesis. This seems to rule out the explanation that the preference for negation in concession would be reflected in shorter reading times only after a delay. A further time-course manipulation will be introduced in Experiment 3.

Experiment 3

Predictions

This third experiment further examines the time-course of negation processing and its impact on concession by adding a second spill-over region, following Lyu et al. (2019). This added segment will allow us to see whether the negation effect is stable over time. The hypotheses are the same as those in Experiment 2: reading times for negative concession and negative result are expected to further decrease towards the end of the sentence, thus leading to a larger difference between polarities for concession and a smaller one for result. The analysis will focus on the regions of interest, namely the critical segment and two spill-over segments.

Participants

Four new groups of 20 participants (80 in total) were recruited on Prolific and remunerated (£1.75). Participants were 65% female, aged 32 on average (18-67yo).

Materials and procedure

The items and fillers were the same as in Experiment 1, except that a second spill-over region was added, as in Lyu et al. (2019). This segment only contained neutral commentaries or complements that did not affect the interpretation of the discourse relation and were identical across conditions. Some examples of this region include: *in my opinion, next week, in general, every time, with his friend*, etc. A complete example is illustrated in (14).

- (14) The students had an upcoming exam. // They all knew their coursework well // and they [Segment 1] // were confident [Segment 2] // about their performance [Segment 3] // at this exam. [Segment 4]

The rest of the procedure is the same as Experiment 1. Contrary to Experiment 2, no delay was added before the connective region. Participants took about 18 minutes to complete the study on average.

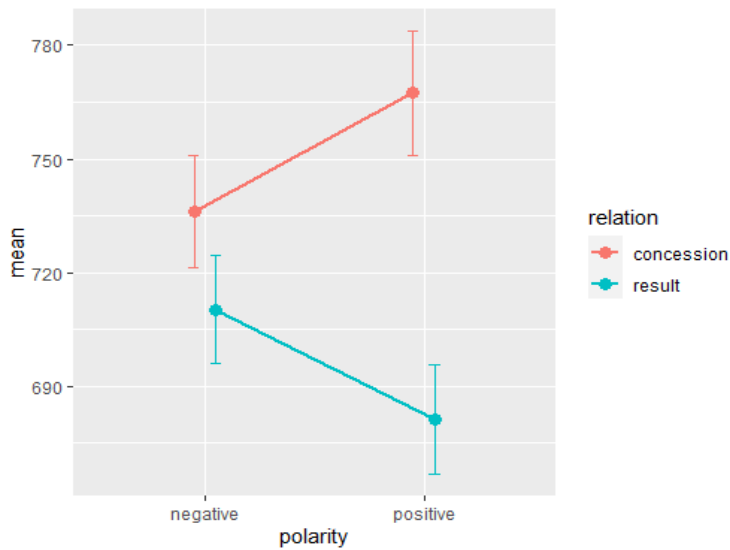
Results

Extreme values ($n=44$) and outliers ($n=529$; 3.4% of the data) were dealt with following the same procedure as before.

Segment 2. This is the critical region. The model with random intercepts by participant and by item (models with random slopes failed to converge) was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 20.26$, $\Delta df = 1$, $p < .001$). Adding Polarity to this model did not further improve it ($\Delta\chi^2 = 3.72$, $\Delta df = 2$, $p = .16$). The final model ($RT \sim \text{Relation} + (1 | \text{Participant}) + (1 | \text{Item})$) returned a main effect of Relation, with faster reading times after result ($M = 637\text{ms}$; $SD = 362$) than after concession relations ($M = 685\text{ms}$; $SD = 448$) ($\beta = 24.86$, $SE = 5.52$, $t = 4.51$, $p < .001$).

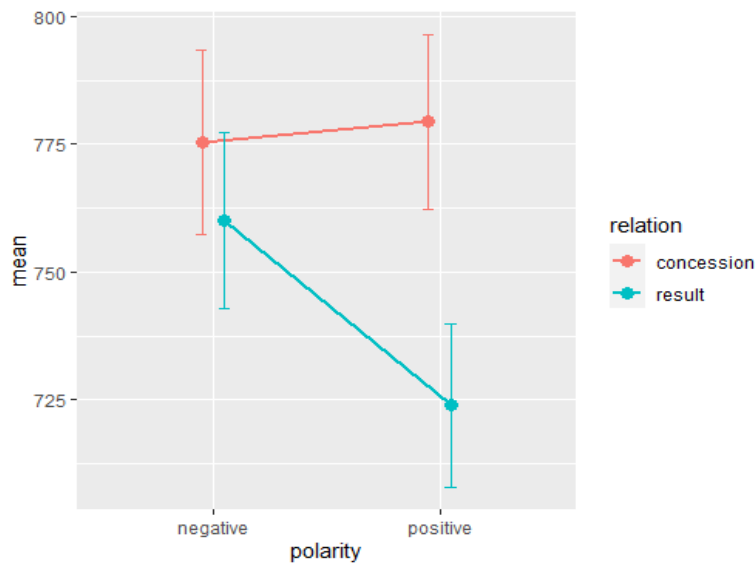
Segment 3. This is the first spill-over region. The model with random intercepts by participant and by item and random slope for Relation by participant was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 15.62$, $\Delta df = 1$, $p < .001$). It was further improved by adding Polarity ($\Delta\chi^2 = 7.22$, $\Delta df = 2$, $p < .05$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 + \text{Relation} | \text{Participant}) + (1 | \text{Item})$) returns a main effect of Relation, with faster reading times after result ($M = 696\text{ms}$; $SD = 403$) than after concession relations ($M = 751\text{ms}$; $SD = 435$) ($\beta = 29.53$, $SE = 7.16$, $t = 4.13$, $p < .001$). There is no main effect of Polarity ($\beta = 0.73$, $SE = 5.59$, $t = 0.13$, $p = .9$). However, the interaction between Relation and Polarity is significant ($\beta = -15.01$, $SE = 5.59$, $t = -2.69$, $p < .01$). More specifically, differences between relations are only significant in the positive condition. Differences between polarities within a given relation are not significant, as can be seen on Figure 5.

Figure 5. Mean reading times by condition on Segment 3 (Experiment 3)



Segment 4. This is the second spill-over region. The model with random intercepts by participant and by item (models with random slopes failed to converge) was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 7.52$, $\Delta df = 1$, $p < .01$). Adding Polarity did not further improve it ($\Delta\chi^2 = 3.41$, $\Delta df = 2$, $p = .18$). The final model ($RT \sim \text{Relation} + (1 \mid \text{Participant}) + (1 \mid \text{Item})$) returns a main effect of Relation, with faster reading times after result ($M = 741\text{ms}$; $SD = 467$) than after concession relations ($M = 777\text{ms}$; $SD = 491$) ($\beta = 19.24$, $SE = 7.01$, $t = 2.74$, $p < .01$). The mean reading times for all conditions are reported on Figure 6.

Figure 6. Mean reading times by condition on Segment 4 (Experiment 3)



Discussion

This experiment with an extra spill-over region replicated the main findings from Experiment 2, in particular the reduced effect of negation, which is only significant on the critical segment. The added region did erase differences for result relations, but did not allow a significant difference to emerge between negative and positive concession. This manipulation was used by Lyu et al. (2019) to find an effect of plausibility across cause and concession, and polarity was not counter-balanced across relations. It is therefore possible that pragmatic effects such as plausibility, which affect the discourse model, develop over time, whereas more sentence-level effects such as negation are processed more incrementally (Nieuwland & Kuperberg, 2008). It remains that the difference between concession and result consistently disappears when a negative verb is used in the first clause of the relation, thus cancelling the baseline difficulty of concessive relations otherwise observed in positive polarity.

The use of the connective *and* in the result and concessive items could affect the processing of the relations, since it leaves the exact relation underspecified (no explicit information can be inferred from the connective alone). In order to see whether the pattern of

findings would change with more explicit connectives, and in particular in order to test whether the interaction between polarity and relation would disappear, Experiment 4 will modify the connective region of the materials used so far.

Experiment 4

Predictions

In this final experiment, the connective *and* is replaced by more explicit connectives, namely *so* for result and *but* for concession. By making the discourse relations explicit sooner (i.e. as soon as the connective is encountered, rather than at the critical region only), this manipulation may affect reading times as well as sense ratings. For the former, we can still expect a facilitation effect of negation on concession: by removing the difficulty of implicit concession (through *but* instead of *and*), the ceiling effect will disappear and a difference between positive and negative concession might emerge, with faster reading times for negative concession. The effect of negation (speeding up concession vs. slowing down result) should occur as soon as the connective region, where the relation is already indicated by the semantics of the connective. Regarding the latter, sense ratings are expected to be higher for concessive items than in the previous experiments, as *but* will make these items more acceptable than *and*.

Participants

A new group of 82 participants was recruited on Prolific and remunerated (£1.75). Participants were 65% female, aged 36 on average (19-77yo).

Materials and procedure

The items and fillers were the same as in Experiment 3, except that the connective was changed according to the discourse relation: result items were presented with *so* and concessive items with *but* instead of the ambiguous *and*. Here are the new four conditions for Example (14) above (*The students had an upcoming exam*):

- (15) They all knew their coursework well // so they // were confident // about their performance // at this exam. [positive result]
- (16) They didn't know their coursework // but they // were confident // about their performance // at this exam. [negative concession]
- (17) They didn't know their coursework // so they // were anxious // about their performance // at this exam. [negative result]
- (18) They all knew their coursework well // but they // were anxious // about their performance // at this exam. [positive concession]

With this design, polarities and relations are still counter-balanced, although the three-way combination of polarity, connective and critical word is not fully crossed. This would result in implausible scenarios, such as **They all knew their coursework well so they were anxious about their performance*. As already mentioned above, plausibility is included in previous studies (Xu et al., 2018; Lyu et al., 2019) and is not directly relevant to the present research questions. As in Experiment 3, the materials are presented with two spill-over regions and no delay.

The procedure is the same as in the previous experiments. Participants took about 20 minutes to complete the study on average.

Results

Sense ratings.

I only report mean ratings for the critical items, as shown in Table 2. We see that the pattern of results is exactly the same as in Experiment 1, with a preference for positive polarity in result, negative polarity in concession, and higher scores in result overall. However, as predicted, mean scores for concession are higher with *but* than they were with *and* in Experiment 1 (less than four).

Table 2. Average sense ratings by relation and polarity (Experiment 4)

	result	concession	Total
positive	6.15	5.18	5.67
negative	5.88	5.43	5.66
Total	6.02	5.31	5.66

A linear model with random intercepts and slopes for Relation by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 29.39$, $\Delta df = 1$, $p < .001$). Adding Polarity to this model further improved it ($\Delta\chi^2 = 33.28$, $\Delta df = 2$, $p < .001$). The final model (Ratings $\sim$ Relation * Polarity + (1 + Relation | Participant) + (1 + Relation | Item)) returned a main effect of Relation, with higher scores for result than for concession relations ($\beta = -0.35$, $SE = 0.06$, $t = -6.03$, $p < .001$). There is no main effect of Polarity. However, the interaction between Relation and Polarity is significant ($\beta = 0.13$, $SE = 0.02$, $t = 5.77$, $p < .001$). All differences are statistically significant in this interaction.

Reading times.

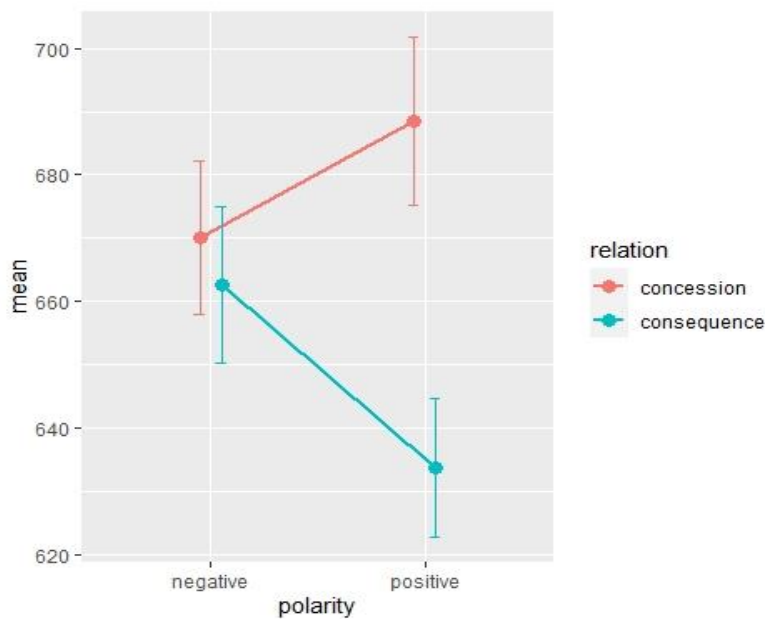
Extreme values ($n=53$) were removed and outliers ($n=523$; 3.2% of the data) were replaced by their cut-off, as in the previous experiments.

Segment 1. This is the connective region. As a reminder, the connective is either *so* for result or *but* for concession, which should already cue the participants as to the type of relation. Thus, contrary to the previous experiments, we can expect an effect of relation on

Segment 1. However, the model with random intercepts by participant and by item (models with random slopes failed to converge) was not significantly improved by adding Polarity as predictor ($\Delta\chi^2 = 0.37$, $\Delta df = 1$, $p = .54$) nor by adding Relation ($\Delta\chi^2 = 0.05$, $\Delta df = 1$, $p = .82$).

Segment 2. This region corresponds to the verb phrase and stops after the critical (disambiguating) word, reinforcing the interpretation of the connective. The model with random intercepts by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 10.27$, $\Delta df = 1$, $p < .01$). Adding Polarity to this model further improved it ($\Delta\chi^2 = 7.34$, $\Delta df = 2$, $p < .05$). The final model ($RT \sim \text{Relation} * \text{Polarity} + (1 | \text{Participant}) + (1 | \text{Item})$) returned a main effect of Relation, with faster reading times after result ($M = 648\text{ms}$; $SD = 332$) than after concession relations ($M = 679\text{ms}$; $SD = 360$) ($\beta = 14.68$, $SE = 4.58$, $t = 3.21$, $p < .01$). There was also a significant interaction between Relation and Polarity ($\beta = -12.24$, $SE = 4.58$, $t = -2.67$, $p < .01$). Pairwise comparison to examine the interaction effect shows that only the difference between positive result ($M = 634\text{ms}$; $SD = 311$) and positive concession ($M = 689\text{ms}$; $SD = 378$) is significant ($p < .01$), as shown on Figure 7.

Figure 7. Raw reading times by condition on Segment 2 (Experiment 4)



Segment 3. This is the first spill-over region. The model with random intercepts by participant and by item was significantly improved by adding Relation as predictor ($\Delta\chi^2 = 5.73$, $\Delta df = 1$, $p < .05$). Adding Polarity to this model did not further improve it ($\Delta\chi^2 = 0.07$, $\Delta df = 2$, $p = .97$). The final model ($RT \sim \text{Relation} + (1 \mid \text{Participant}) + (1 \mid \text{Item})$) returns a main effect of Relation, with faster reading times after result ($M = 727\text{ms}$; $SD = 383$) than after concession relations ($M = 752\text{ms}$; $SD = 404$) ($\beta = 12.72$, $SE = 5.31$, $t = 2.39$, $p < .05$).

Segment 4. This is the second spill-over region. The model with random intercepts by participant and by item was not significantly improved by adding Relation as predictor ($\Delta\chi^2 = 0.5$, $\Delta df = 1$, $p = .48$) nor by adding Polarity ($\Delta\chi^2 = 0.09$, $\Delta df = 1$, $p = .76$). Therefore, as in the connective region, there is no significant difference between positive vs. negative or result vs. concession items.

Discussion

This last version of the experiment with explicit connectives removed some of the effects observed before. First, against my expectations, there was no difference between conditions on the connective region, although the discourse relation was already cued at this stage. This could suggest strategic reading whereby participants wait till later in the sentence before they actually process the discourse relation. Secondly, the effect of polarity was not significant in any of the spill-over regions, which may indicate that any difficulty associated with negation did not last after the critical segment, once the participants had all the relevant content to process the discourse relation. By contrast, the interaction between relation and polarity was once more significant in the critical region, which replicates the findings from the previous experiments and confirms the central hypothesis. In this version again, there was no difference between result and concession when the first clause is negative. Still, the use of an explicit connective did not remove the difference between relations entirely, with a

significant main effect at the critical segment and first spill-over region. This result therefore rules out the possibility that the pattern of findings observed in Experiments 1–3 was due to a ceiling effect of complexity linked to the use of the ambiguous connective *and*, that is, *and* being so difficult to process that it prevents any further differences to emerge (for instance between negative concession and negative result, which remain similar when connected by *but*). It does appear, on the contrary, that there is a robust facilitation of negation in concession, whereby negative concession is not harder to process than its positive equivalent, unlike the pattern in result relations.

This polarity bias was also confirmed once again offline with the sense ratings, replicating perfectly the interaction from Experiment 1, with the important exception that mean ratings for concessive items are higher with *but* than with *and*. Although this was a between-group manipulation and no direct comparison is available, this could indicate that participants were (negatively) influenced by the connective in Experiment 1. This effect of connective type in offline ratings was however not carried over to the online data, since the effects were largely similar across experiments, although not always in the same regions.

General discussion

I conducted four self-paced reading experiments that tested whether negation can facilitate the processing of concessive relations. The experiments manipulated the type of discourse relation (result vs. concession) and the overt polarity of the verb in the first clause of that relation (positive vs. negative, e.g. *knew* vs. *didn't know*). Experiment 1 supports the central hypothesis that negation cancels the processing difference between result and concession. In this experiment, where the clauses of all relations were connected by *and*, there was a significant baseline effect of relation which confirmed that concession is more difficult to process than result overall (e.g. Townsend, 1983). This difference was erased

when the verb of the first clause was negative, which shows that negation can modulate discourse-level processing and impacts result and concession differently.

Following previous studies, additional variables were manipulated in follow-up experiments. Experiments 2 and 3 investigated the time-course of the effect of negation on concession by adding a 1,500ms delay (as in Kaup et al., 2006) and by adding a second spill-over region (as in Lyu et al., 2019), respectively. These manipulations showed that the slow-down effect of negation in result disappeared over time, but they did not remove the interaction between relation and polarity and confirmed in particular that differences between relations are only significant in the positive items. Finally, Experiment 4 replicated the findings by replacing *and* with *but* and *so* in order to address a potential ceiling effect in concession. Despite these more explicit connectives, concession remains more difficult than result overall, and the same interaction was once more observed on the critical region, thus confirming the robust facilitation effect of negation on concession.

In the following, I discuss some of the theoretical and methodological implications of these findings.

Difficulty and time-course of processing negation

This study follows a large body of research on the processing of negation. Previous research has focused on measuring the cost of negation and identifying conditions where this cost is alleviated (e.g. Johnson-Laird & Tridgell, 1972; Nieuwland & Kuperberg, 2008; Tian et al., 2016). The present findings lend some support to accounts such as Kaup et al.'s (2006) two-step processing, according to which negative sentences are more complex than affirmative ones. In Experiment 1, reading times on the connective region were marginally significantly longer when the verb of the first clause expressed negative polarity compared to its positive counterpart.

The presence of an initial sentence setting the context did not affect the difficulty of negation: this first sentence was only designed to give a broad context in which participants could better integrate the critical part of the items (i.e. the discourse relation), and did not “license” the negation (Nieuwland & Kuperberg, 2008). As a result, although the negative clause was not technically “discourse-initial” (Tian & Breheny, 2018) in the short passages, it did not benefit from any of the negation-friendly conditions identified in previous studies. The present findings thus confirm that out-of-the-blue negation induces an immediate cost which is clearly observable in reading times at the sentence level.

This study also addresses the effect of time on the processing of negation, that is, whether the difficulty associated with negation is long-lasting or fades away after a delay. The main effect of polarity, observed at the connective and critical regions in Experiment 1 (no time manipulation), was no longer significant in any region of Experiments 2 and 3, which could already suggest that negation is affected by the temporal unfolding of the sentence. In addition, in Experiment 1, the slow-down effect of negation on result relations that was found at the critical region was no longer significant in the spill-over region. The difference between positive and negative result was never observed in the follow-up experiments with more delay or more regions, which suggests that the cost of negation in result is immediate and brief. These findings lend some support to Kaup et al. (2006), who found that comprehenders need some time to represent the “actual state of affairs” after having rejected the negated one (e.g. *door not closed* vs. *open door*).

Negation as a cue for concession

The main contribution of this study lies at the discourse level, where negation was shown to modulate the processing of concessive and result relations. In particular, Experiments 1–4 all found that differences between concession and result relations were

significant in the positive polarity, not in negative items. These findings suggest that result and concession have an opposite preference for positive and negative polarity, respectively. They show that general categorizations of discourse relations as more or less cognitively complex (as in Hoek, Zufferey, Evers-Vermeul, & Sanders, 2017) do not necessarily hold in all contexts and can be modulated by the amount of information provided in the segments of the relation. Furthermore, while the cost of negation was reduced over time, the polarity preference for result and concession remained stable, with a persistent difference between positive concession and positive result across all regions and experiments, suggesting that discourse-level processing retains some information of polarity even after the cost of negation has disappeared.

This finding was obtained through an innovative approach to the issue. The study indeed stands in sharp contrast with previous research that all focused on the effect of sentence-initial connectives on the processing of negation (e.g. Morera et al., 2017; Xu et al., 2018; Lyu et al., 2019) rather than on the effect of negation itself on subsequent linguistic material. We can therefore conclude that the interaction between polarity and discourse relations is mutual and bi-directional: not only do some relations facilitate the processing of negation, but initial (i.e. first-clause) negation itself modulates the processing of an upcoming relation. The present findings have thus established negation as a concessive facilitator that cancels the baseline difference between result and concession.

This study contributes to a growing line of research investigating the role of contextual cues other than connectives in the processing of discourse relations. After prosody (Didirkova et al., 2018), adverbs (Schwab & Liu, 2020), complementizers (Rohde et al., 2017), structural parallelism (Crible & Pickering, 2020) and verb tense (Grisot & Blochowiak, 2019), overt verb polarity thus appears to enter the family of discourse-relevant information. This family is potentially endless, as discourse is among the higher levels of

processing and, as such, integrates information from all subordinate levels. Whether and how these different sources of information interact in production and comprehension is a vast area of research that only begins to be uncovered.

One further element that this study brings to this issue is the impact that negation has on different connectives. Crible and Pickering (2020) showed that, in contrastive relations, the facilitation effect of parallelism is stronger with *and* than with *but*. Similarly, here, there were more significant differences in Experiment 1 (with *and*) than in Experiment 4 (with *but* and *so*). More specifically, in the latter, the connective and second spill-over regions did not show any main effect; the effect of relation was observed at the critical and first spill-over region, and the targeted interaction was only found at the critical region. In other words, while all experiments return the same interaction at some point, thus confirming that the affinity between negation and concession holds across the board, this effect might be larger with *and*. This might suggest that using *and* in the previous experiments enhanced the differences between conditions by creating an added difficulty. This is also reflected in the higher ratings scores for concession with *but* than with *and*. The ambiguity of *and* has often been associated with difficulty, as it leaves the exact relation underspecified and therefore requires more inferencing (Spooren, 1997; Cain & Nash, 2011).

Nevertheless, reading times at the critical regions of Experiments 1 and 4 were largely similar and the interaction was successfully replicated. This, added to the fact that this pattern of results was already found in other studies where specific connectives were used (e.g. Morera et al., 2017; Lyu, 2019), convincingly shows that the discourse effects of negation hold despite more local differences (with or without delay, with ambiguous or explicit connectives). The present study thus brings together multiple factors that may affect the processing effect of negation and shows for the first time that negation is not always on the

receiving end of previous contextual manipulations but can itself have an impact on how the following words are processed.

Methodological implications

The experiments included in this study all combined the self-paced reading paradigm with a sense rating task, thus providing both online and offline data. We saw that they were largely consistent with each other. This converging evidence further attests of the robustness of the interaction. However, the preference for negative polarity in concession was more marked in offline ratings than in reading times, where the difference between polarities in concession never reached significance. This is relatively surprising given that explicit judgments over discourse relations are notoriously hard to capture reliably, and procedural meaning is hard to access consciously (Blakemore, 2002; Zufferey, Mak, Degand, & Sanders, 2015). This mismatch between offline and online data, albeit minor, points to a number of methodological issues related to self-paced reading and to web-based experiments in general.

Firstly, it is worth noting that the self-paced reading method used for this study was sensitive enough to identify a robust pattern of facilitation across all experiments. The simplicity of this method should not alter the validity of the results. However, the expected effects did not always appear in the same regions: for instance, the interaction was significant at the critical region for all experiments except Experiment 3, and again at the first spill-over region for all experiments except Experiment 4. It is well-known that self-paced reading is not very time-sensitive, that the segmentation of materials brings up issues of ecological validity and that strategic reading can happen when participants quickly move to the final segment before processing the whole sentence (e.g. Jegerski, 2014). Combining this study with other methods such as eye-tracking and event-related potentials would therefore refine

the results and could provide more consistency in the location and time-locking of the observed effects.

Secondly, individual differences and item variation may have prevented a robust difference between positive and negative concession. As a reminder, I expected negative concession to be read faster than its positive version. This effect can be seen on all graphs in the expected direction, with up to 50ms mean difference on the spill-over region of Experiment 1, but never reaches significance. Closer inspection of the data reveals that the mean reading times across conditions follow the expected pattern for 22 items (i.e. negative faster than positive concession), are reversed in 14 items (i.e. negative concession longer) and do not differ for the remaining four items in the materials. In addition, the standard deviation was always quite large and showed substantial differences between participants. This echoes Zufferey and Gyga's (2020) recent study where they showed that some participants are more sensitive to discourse-level information (such as connectives) than others. It may also relate to the fact that concession is inherently a subjective relation, where the negated causal inference largely rests on the comprehender to be reconstructed (Verhagen, 2005). Age differences between participants (with a few over 60yo in each experiment) may have had an effect in this respect. Running experiments on web-based platforms such as Prolific adds another layer of potential variation, since participants might not feel as compelled to remain focused as in a lab setting and can take unmonitored breaks (Enochson & Culbertson, 2015). Furthermore, this study does not involve ungrammatical or highly disruptive manipulations (e.g. garden-path effects), which makes it harder to find strong effects. Still, the pattern of results is stable enough to be replicated in three follow-up experiments, which vouches for the reliability of the method.

As for the non-significant difference in reading times between positive and negative concession, it does not remove the strength of the interaction, since one could have expected

negative concession to be read more slowly than all other conditions if the individual costs of negation and concession (observed through the baseline main effects) were adding to each other instead of cancelling each other. The present experiments, despite their methodological shortcomings, do establish a modulating effect of negation on discourse processing.

Conclusion

While sentence-level processing of negation has been heavily documented, its role at the discourse level has received less attention. The present study investigated the effect of negative vs. positive polarity on the processing of concessive and result relations, with the central hypothesis that negation would facilitate the processing of an upcoming concession. Four self-paced reading experiments were conducted and showed a robust interaction between polarity and relation, confirming the role of negation as a concessive facilitator. More research is needed to determine whether this effect of polarity is restricted to the two relations under scrutiny here or can instead be extended to others like contrast, which is also defined as a “negative” relation (Sanders et al., 1992). Furthermore, combination with more time-sensitive behavioral and neurological methods such as eye-tracking and event-related potentials could refine the present findings, in particular those related to the precise time-course of negation processing.

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