Compensating for processing difficulty in discourse

Effect of parallelism in contrastive relations

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Abstract

This study aims to establish whether the processing of different connectives (*and*, *but*) and different coherence relations (addition, contrast) can be modulated by a structural feature of the connected segments, namely parallelism. While *but* is mainly used to contrast two expressions, *and* occurs in many different relations and has been shown to come with a processing cost. We report three self-paced reading experiments in which we manipulate whether the connected segments share a common verb phrase. Such parallel constructions frequently occur in contrastive relations, although they are typically treated as additive in comprehension research. We expect that parallelism will compensate for the cognitive complexity of contrast and for the ambiguity of *and*, by further signalling the coherence relation. Our results indicate that parallelism speeds up processing, and provide further evidence for priming in comprehension. However, parallelism interacted with connective ambiguity in an overt disambiguation task (Experiment 3), but not in a more natural reading task (Experiment 2). We argue that the processing of contrast remains shallow unless disambiguation is explicitly required.

Keywords: discourse connectives, ambiguity, parallelism, self-paced reading, contrastive relations

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Introduction

Discourse connectives – optional linguistic expressions such as *and*, *but* or *because* – are the typical signals for coherence relations (e.g. cause, contrast, condition) that link clauses and create text coherence (Halliday & Hasan, 1976; Sanders, Spooren, & Noordman, 1992). Discourse processing and comprehension are often studied through the lens of connectives, and the past three decades have seen ample psycholinguistic evidence of their facilitating role as processing instructions (Millis & Just, 1994; Sanders & Noordman, 2000). However, some connectives are more informative than others and some relations rely more on connectives than others (Murray, 1997; Cain & Nash, 2011; Kleijn, Pander Maat, & Sanders, 2019). In addition, connectives are not the only type of linguistic signals that can make coherence relations (more) explicit: a range of semantic and syntactic devices have been shown to contribute to relation signalling (Das & Taboada, 2018), even though their processing effect remains largely unknown.

In this paper, we report three self-paced reading experiments that measure the processing cost of the ambiguous connective *and* in sentences involving contrastive relations, such as (1). More specifically, we test whether lexical-syntactic parallelism compensates for the ambiguity of *and*, as opposed to its stronger (i.e. less ambiguous) competitor *but* and to sentences without such parallelism (2).

(1) Nick makes the most delicious cakes and Grace makes the most disgusting desserts.

(2) Nick is excellent at baking and Grace makes the most disgusting desserts.

In (1), the contrast between Nick and Grace is heightened by the repetition of the verb phrase “makes the most”, despite the ambiguous instruction of *and*, which is more

frequently found in relations of addition than contrast (e.g. Prasad, Webber, & Lee, 2018). In (2), there is no such parallelism, the contrastive relation is less explicit and we therefore propose it should be more difficult to process. Parallelism can thus be considered as a discourse signal that contributes to the explicit marking of contrast. These structures can also be found in additive relations, where the relationship between conjuncts is one of similarity, as in (3).

(3) Nick makes the most delicious cakes and Grace makes the most tasteful desserts.

The interaction between connectives and other discourse signals is a recent and growing line of research in corpus linguistics (Das & Taboada, 2018; Hoek, Zufferey, Evers-Vermeul, & Sanders, 2019). For instance, from a production perspective, Crible (in press) found that discourse signals co-occur more frequently with *and* than with stronger connectives; she further identified parallel constructions as reliable predictors of contrast. However, very few studies have addressed this interaction in comprehension through experimental methods (but see Grisot & Blochowiak, 2019). The present experiments address this gap and test whether parallelism can compensate for the processing cost of *and* in contrastive relations, as parallel constructions have been shown elsewhere to speed up reading times (Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984).

Studies on the role of linguistic signals in discourse processing, and of parallelism in particular, are reviewed in the next sections, along with our hypotheses. We then present the method and results of three self-paced reading experiments that target the impact of parallelism across coherence relations (Experiment 1), across connectives (Experiment 2) and in an overt disambiguation task (Experiment 3). We discuss these findings and provide some conclusions in the final section.

The processing of coherence relations and their signals

Coherence relations such as contrast or consequence play a central role in the mental representation of a discourse (Sanders et al., 1992). They are defined as "an aspect of meaning of two or more discourse segments that cannot be described in terms of the meaning of the segments in isolation" (Sanders et al., 1992, p. 2). As such, they can but do not have to involve a causal inference. Relations differ in their cognitive complexity and ease of processing (Trabasso & Sperry, 1985; Trabasso & van den Broek, 1985; Sanders & Noordman, 2000). In particular, relations that involve a reasoning process (so-called subjective relations, such as *The neighbours must be out because their lights are off*) have been repeatedly shown to cause a processing delay compared to their objective equivalent, which connects facts (e.g. *The neighbours are out because they had an appointment*) (Traxler, Bybee, & Pickering, 1997; Canestrelli, Mak, & Sanders, 2013). Similarly, negative relations such as concession (e.g. *The neighbours are out although their lights are on*) are more complex to process than their positive equivalent because they require the denial of an inference from one of the segments (Xu, Jiang, & Zhou, 2015). Negative relations are also acquired later than positive relations (Bloom, Lahey, Hood, Lifter, & Fiess, 1980; Evers-Vermeul & Sanders, 2009), which further indicates their complexity.

Many researchers consider connectives as procedural instructions that facilitate the processing and comprehension of coherence relations (e.g. Canestrelli et al., 2013; van Silfhout, Evers-Vermeul, & Sanders, 2015). This was shown by comparing explicit and implicit relations (i.e. with or without a connective). In particular, studies have found that sentences are read faster (Sanders & Noordman, 2000) and that comprehension questions are answered faster and more accurately (Millis & Just, 1994) with a connective than without one.

However, the facilitative effect of connectives does not seem to apply to *and*. Cain and Nash (2011) showed that reading times for *and* used in temporal, causal or adversative relations were longer than other connectives (e.g. *because* in causal or *but* in contrastive relations). This processing difficulty of *and* can be explained by the different frequencies with which it expresses various relations: its primary meaning is additive, with secondary uses in consequence, specification or contrast, among others (Prasad et al., 2018). As such, *and* is similar to other ambiguous words that exhibit processing differences between their primary and secondary meaning (e.g., *bank*); see for example Duffy, Morris, and Rayner (1988). At the discourse level, Zufferey, Mak, Degand, and Sanders (2015) also observed that the less frequent meaning of the ambiguous connective *while* (i.e. contrastive) is more difficult to identify than its dominant temporal meaning.

In contrast, *but* is overwhelmingly adversative (concessive or contrastive) in corpora (Prasad et al., 2018). This difference in meaning between *and* and *but* is further evidenced by Koornneef and Sanders's (2013) study, where participants' continuations of sentences after *and* were found to match a much larger number of relations (additive, result, temporal, contrastive, cause, other) than *but* or *because*, which were completed by contrastive and causal continuations, respectively. Differences in processing difficulty between connectives, as observed by Cain and Nash (2011), may thus be due to the frequency and accessibility of their meanings: a contrastive relation is much more frequent with *but* than with *and*, and is therefore easier to process.

Parallelism and comprehension priming

This study tests whether parallelism helps overcome processing difficulties in the context of coherence relations expressed by the ambiguous connective *and*. The type

of parallelism that we consider here is the repetition of a verb phrase construction, which involves not only partial lexical repetition but also repetition of the associated argument structure. Studies have shown that parallelism often facilitates comprehension. For example, in their self-paced reading study, Frazier et al. (1984) found that, in conjoined sentences, the second conjunct (after *and*) was read faster when it re-used the same structure as the first conjunct than when the structures were not parallel. Sturt, Keller, and Dubey's (2010) eye-tracking study further found a parallelism effect in both coordinated and subordinated contexts: *X said that Y*, where both *X* and *Y* involve a relative clause, was read faster than *X said that Z*, where *X* is a relative clause and *Z* is an adjective phrase. Such facilitation effects reflect syntactic (or structural) priming in comprehension (see Pickering & Ferreira, 2008).

However, Knoeferle (2014) found that parallelism does not always facilitate processing: she conducted eye-tracking experiments with various conjunctions (German *und* 'and', *aber* 'but' and *während* 'while') and found an effect of parallelism for *and* but not for the two contrastive conjunctions.[1] She explained this interaction by a shared meaning of "resemblance" in both parallelism and the conjunction *und*: she assumed that *und* is a monosemous, unambiguous additive connective that creates the expectation that something similar will follow (as defined in Kehler, 1996); this expectation is then met at the structural level when the structure of the first conjunct is repeated in the second, which speeds up processing. Knoeferle (2014) argued that effects of parallelism are therefore semantically constrained (i.e. modulated by the meaning of the connective) and are not simply due to priming.

In her study, Knoeferle (2014) makes two assumptions: i) that *und*/*and* is always interpreted as additive and ii) that parallel structures always create an expectation of similarity between the conjuncts. The first assumption about the meaning

of *and* is widespread in priming research (e.g. Poirier, Walenski, & Shapiro, 2012; Zhang, Bernolet, & Hartsuiker, 2019), yet it overlooks the ambiguity of the connective and the variability of its meaning-in-context. In the present study, we challenge this monosemous view of *and* as a strictly additive connective and stress that the relation between two conjuncts can be one of contrast, as a result of contextual inferences (Spooren, 1997).

As for the second assumption, there is evidence that parallelism is not restricted to meanings of similarity. Kehler (1996) defines "parallel" and "contrast" as two subtypes of the overarching "resemblance" coherence relation, and his example for contrast involves an elided (or "gapping") parallelism: *John voted for Clinton but Tom for Bush*. In addition, a recent corpus study by Crible (in press) shows that parallel constructions occur both in contrastive and additive relations, but are significantly more frequent in the former, as in her corpus-based example (4).

(4) You can't overdose and die by smoking too much marijuana, whereas with alcohol, you can overdose and die by drinking too much.

These observations indicate that parallelism is fully compatible with contrastive relations and can serve to highlight differences between two clauses. We set out to test whether such contrastive uses of parallelism also play a role in comprehension, by measuring how the facilitation effect of parallelism interacts with different relations (addition, contrast) and different connectives (*and*, *but*).

A discourse-functional account of parallelism in coherence relations

To summarize, the present study brings together three discourse-relevant factors in the comprehension of coherence relations: the complexity of the coherence relation

(addition vs. contrast), the ambiguity of the connective (*and* vs. *but*), and the structure of the conjuncts (parallel vs. non-parallel). While each of these variables has been individually tested before, their interaction is expected to provide a multi-variate account of the processing of contrastive relations. Our manipulation of parallelism across relations (additive vs. contrastive) is particularly novel, as this structural feature was previously assumed to only generate expectations of similarity (Knoeferle, 2014; Zhang et al., 2019). Furthermore, our focus on *and* as an ambiguous connective of addition and contrast will help refine previous accounts of discourse comprehension.

One challenging aspect of studying the processing of coherence relations is the semantic manipulation of the relation: how to make sure that the materials actually represent the target coherence relation? Most studies have relied on the semantics of the connectives (e.g. Murray, 1997), but as we have shown in the previous sections, connectives do not always provide straightforward instructions in comprehension. More specifically, the assumption that changing the connective from *but* to *and* (or *vice versa*) changes the coherence relation (as in Knoeferle, 2014) overlooks the fact that *and* is compatible with both positive (additive) and negative (contrastive) relations.

Against this backdrop, we designed three self-paced reading experiments in which the coherence relation depends on the content of the segments rather than on the connective alone. As a result, the connective does not determine the type of relation but acts as a facilitator – an optional instruction that may or may not ease the processing of the relation. Because of the higher frequency of *and* in additive relations compared to contrastive relations, we expect that this connective facilitation will be stronger with the former – that is, addition will be easier to process than contrast (Experiment 1). For the same frequency-based reason, contrast is expected to be more difficult to process when it is marked by *and* than by *but* (Experiment 2). Such findings would confirm the

processing cost that Cain and Nash (2011) observed for *and* compared to less ambiguous connectives. In addition, parallel structures are expected to be read faster than non-parallel conjuncts across the board, as a basic and pervasive priming effect similar to previous studies (Frazier et al., 1984).

Besides these three main effects, we test for two interaction effects for parallelism across relations and across connectives. The first interaction is such that the facilitation of parallel structure is expected to be stronger in contrast than in addition. Contrary to Knoeferle (2014), who assumes that parallelism always indicates similarity, we take into consideration the attested cases of parallel structures in contrastive relations as well. The higher cognitive complexity of negative relations suggests that the effect of parallelism would be larger in contrast than in addition. Additive relations are assumed to be cognitively simpler to process, and therefore the facilitation effect of parallelism will be reduced.

We further test for a second interaction between parallelism and connectives: within one coherence relation (contrast), differences between parallel and non-parallel structure should be larger with *and* than with *but*. Because the processing instruction of *and* is ambiguous and contrastive uses of *and* are infrequent, participants will rely on the parallel structure to infer the contrast; conversely, *but* is a dedicated contrastive connective, so that parallelism will be redundant with its instruction and its facilitation effect will be smaller.

Finally, Experiment 3 addresses a methodological concern related to the online disambiguation of the relation: how can we know which relation participants are interpreting? Careful design of the materials, even with pre-testing, cannot guarantee that the intended relation will be accurately identified online for every trial and every participant. Comprehension studies do not report on this issue, even when they include

ambiguous connectives like *and*. Task design also differs between studies: Murray (1997) had no background task, whereas Cain and Nash (2011; Experiment 3) included a coherence judgment question after each trial in their self-paced reading experiment. It may be that the processing of ambiguous connectives will remain shallow and participants will not infer a specific coherence relation unless the task design demands it, as was shown for other underspecified phenomena outside coherence relations (Frisson & Pickering, 1999; Pickering, McElree, Frisson, Chen, & Traxler, 2006). In two ERP experiments on the concessive connective *even so*, Xiang and Kuperberg (2015) showed that task had an impact on discourse processing such that, when forced to make a coherence judgment, participants committed to a specific interpretation, whereas such commitment was not found without a background task. Differences in processing cost might therefore be reinforced in an active task design.

In sum, our experiments bring together discourse processing studies and parallelism research. They closely relate to Knoeferle's (2014) study on the interaction between parallelism and connectives and adopt a fine-grained approach to the investigation of *and* and of parallelism. In doing so, we keep connectives, relations and parallelism as independent factors, which allows us to test for their interaction.

Experiment 1: Parallelism across relations

The first experiment tests the effect of parallelism across relations with different degrees of cognitive complexity. It focuses on the connective *and* used in either additive or contrastive relations.

Participants

A total of 136 participants (native English speakers from the United States, Canada, United Kingdom, Republic of Ireland, New Zealand or Australia; 66% female, aged 18-66) took part in this study. They were recruited on Prolific, an online platform for research participants, and were remunerated £2 for their contribution. On Prolific, participants are invited to take part if they meet the pre-screening criteria (in this case, first language). The study was advertised as follows: "In this study, you will be asked to read English sentences and to answer some simple questions." The sample size was determined for all three experiments in the study. It follows Brysbaert's (2019) recommendation of 110 participants for a two-by-two within-participant design, slightly enhanced to cope with the potential noise of web-based experiments.

Materials

We designed 40 pairs of sentences that represent either a contrastive or an additive relation between the connected clauses. We define contrast here as the comparison between two states of affairs whereby the two states are described as different. Addition, in turn, corresponds to cases in which the two conjoined states of affairs are described as similar. These relations were operationalized by antonyms or synonyms in the first and second clauses. More specifically, we manipulated the coherence relation by changing one word from the first segment to an opposite word, such as "low-budget" versus "expensive". Example materials are provided in Table 1. All sentences were in the present tense and both conjuncts began with a proper name. The second clause (henceforth S2) was always the same across conditions for a given item. The first clause (S1) had the same number of syllables in both conditions. The people described in each clause always presented a clear difference (for contrast) or a clear similarity (for addition) in their behaviour. No stimulus used morphosyntactic

negation (e.g. “not”, “don’t”) in either clause, since negation has been found to cause processing difficulty since Wason (1959).

For items in the parallel condition, the verb phrase was the same in both S1 and S2, while in the non-parallel condition, the S1 used a different verb construction (different lexeme with different argument structure). Apart from the different verb constructions, the rest of the S1 was kept as similar as possible across conditions. When necessary, we used a longer variant of the first proper name to maintain the same number of syllables across the parallel and non-parallel conditions. Both structures (parallel and non-parallel) were used in combination with addition and contrast. Twenty unique scenarios were designed, and a second version of each scenario was created using opposite lexemes in the S2. This resulted in 40 different sentences. The two versions of each scenario were split in two blocks of trials, in such a way that participants saw the same scenario in a different condition (e.g. additive parallel vs. contrastive non-parallel) in the second half of the experiment.

In addition, 60 fillers were created, using completely different structures (both simple and compound sentences), and were roughly as long as the experimental stimuli. Some fillers used other connectives, such as *since* in (5), and some included non-connective uses of *and* as in (6).

(5) Tiffany loves helping young people since / she is a doctor in a children’s hospital.

(6) Edwin goes to the gym every day to / work on his cardio and to meet friends.

All stimuli were rated by two naïve assistants in terms of the relation that holds between the two segments of the sentences on a seven-point Likert scale: are the behaviours described for the characters in each segment of the sentence similar or

different? The scale from -3 (very different) to +3 (exactly the same) gave the possibility to rate a sentence as 0 if the two segments were judged as neither similar nor different. The two raters differed from the original classification by the first author in less than 10% of all stimuli. These materials were removed and replaced by clearer sentences, which were then re-tested.

This design resulted in four conditions (see Table 1), with 10 trials per condition and always *and* as the connective. Contrastive and additive versions of the same scenario were equal in length. The average length for all items (stimuli and fillers) was 81 characters (*SD* = 8) or 14 words (*SD* = 2).

Procedure

All items were split in two segments, right after the connective (*and* or *but*) for stimuli (so that the second segment was a clause), and roughly in the middle of the whole sentence for fillers, creating segments of similar length to segments in the experimental stimuli. Participants first saw three crosses at the centre of the screen as a fixation point before each item, and had to press the space bar on the keyboard in order to show the first segment. Pressing space then showed the next segment, replacing the first one. After reading the second clause, they were again asked to press the space bar, which then revealed either the comprehension question or the next item starting with three crosses.

Half of the materials (both stimuli and fillers) were followed by a simple comprehension question. The aims of this task were to maintain attentional focus, to distract participants from the actual purpose of the study, and to encourage discourse inferencing. The latter relies on phrasing the questions such that similarities or contrasts between the two segments of the sentence come into focus. For instance, the question

for the additive-parallel example in Table 1 was “Does Nick eat in cheap restaurants?”. Participants had to press the left arrow key if the answer was “no” or the right arrow if the answer was “yes”. There was no time constraint on this comprehension task. There were three practice trials at the beginning of the experiment.

Materials were distributed in four counter-balanced lists of 100 trials each (40 stimuli, 60 fillers), each presented to 34 participants so that each participant saw one version of each item and the same number of items from each condition. 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 four points in the experiment. The experiment was designed on Psychopy (Peirce et al., 2019) and run online. Participants took about 16 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 (Bates, Mächler, Bolker, & Walker, 2015) in R. We always included all independent variables relevant to the design and did not perform model selection in order to provide the full information for all experimental conditions. Statistical power analyses were performed after data collection with the {simR} package (Green & MacLeod, 2016). Finally, following Zufferey and Gygax (2016), 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. The pre-registration form, along with ethics approval, complete materials and analysis scripts for all three experiments, are available at https://osf.io/6tepv/?view_only=f5a2f40e22bd49b2bb3fac79e689a29a.

Results

Eleven participants had less than 80% (1.89-78%) correct answers for the comprehension questions. The reading times from these participants were therefore removed from the analysis. The other participants had a mean of 91.5% (80%-100%), which suggests that they were reading for understanding.

We further identified outliers. We first removed any data point under 50ms (one case) or above 10,000ms (75 cases). 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 (146 cases, 2.9% of the data).

A mixed-effect linear regression was fitted to the data, including the interaction between Relation and Structure and random intercepts by item and by participant. It returned a significant main effect of Structure, with faster reading times after a parallel than a non-parallel structure (ß = -84.0007, *SE* = 30.1342, *t* = -2.788, $p < .01$). A post hoc power analysis based on 1,000 simulations returned a power of 79.70% for this effect size (95% confidence interval: [77.07, 82.15]), which is considered high power by Cohen (1962). The effect of Relation (ß = -34.8552, *SE* = 30.1206, *t* = -1.157, $p = .25$) and the interaction between Relation and Structure were not significant (ß = -0.8845, *SE* = 42.6066, *t* = -0.021, $p = .98$). Estimated conditional means are reported in Table 1.

Discussion

The first self-paced reading experiment showed a robust facilitation effect of parallelism. It does seem that, as originally reported in Frazier et al. (1984), structures are read faster when they are repeated than when they are not. However, our predictions regarding the processing cost of contrast over addition was not confirmed: despite frequency differences between the contrastive and additive uses of *and*, and despite the

difference in polarity between these two relations (and the associated difference in complexity), participants did not take longer to read contrastive sentences connected by *and*, and they were not more sensitive to parallelism in contrast either. This finding does not confirm the assumption in parallelism research (e.g. Knoeferle, 2014) that parallel structures facilitate the processing of relations of similarity over contrast. On the contrary, our data indicates that contrastive relations also benefit from the signalling effect of parallelism.

Two points of discussion are worth mentioning here. The first one is a terminological matter: there is some confusion in the literature about how to label negative relations as either contrastive, concessive or adversative. This group of relations can all be expressed by *but*, and the specific conceptual differences between contrast and concession are notoriously subtle (Zufferey & Degand, 2013). As a result, it is not always clear which exact relation is included in different studies. Murray (1997), for instance, targeted *adversative relations*, which he defines as indicating "that the second sentence *contrasts* or limits the scope of the content of the first sentence" (1997, p. 228, emphasis added). Similarly, Cain and Nash (2011) mentioned *adversative* connectives, but also talked about contrast (2011, p. 439). Upon closer inspection of the types of sentences included in these two studies, it appears that they involve some causal inference, also called denial-of-expectation, which makes them closer to concession than contrast (e.g. "Amy had always loved dogs. Amy wanted a dog but she was not allowed one", from Cain & Nash, 2011, p. 441). Conversely, in our materials, the items were designed to be non-causal, without any background or information that would generate causal expectations, so that they would adhere to a strict definition of contrast, as in Lakoff (1971). Inferences are thus restricted to identifying a similarity

(addition) or a difference (contrast) between the segments. It might therefore be that the processing cost of negative relations is true only in concession, not in contrast.

The second issue relates to the semantic marking of the coherence relations. Both contrast and addition, as subtypes of "resemblance", strongly rely on the semantics of the conjoined clauses (Kehler, 1996). In our materials, the relations were constructed through antonyms and synonyms, and would arguably hold without any connective. To our knowledge, it has not yet been experimentally shown that antonyms are harder to process than synonyms (Herrmann, Chaffin, Conti, Peters, & Robbins, 1979; Sabourin, 1998). On the contrary, judgment tasks even seem to suggest the opposite (Charles, Reed, & Derryberry, 1994). Moreover, there was no background on the characters or events that might have prompted the participants to draw causal inferences regarding the relationships between segments based on their world knowledge. Therefore, it is possible that participants in our study solely relied on semantic cues with equal ease and overlooked the ambiguity of the connective altogether. In any case, whether the non-significant effect of relation type is due to a terminological or a semantic issue cannot be determined on the basis of this experiment, and these explanations are only tentative.

Experiment 2: Parallelism across connectives

While addition and contrast did not significantly differ in reading times when expressed by *and*, it may be that the ambiguity of *and* will show up when its contrastive use is compared with a more specific connective of contrast, namely *but*. The second experiment focuses on contrastive relations and tests the effect of parallelism across connectives with different degrees of ambiguity.

Participants

For this experiment, 132 new participants were recruited on Prolific (66% female, aged 19-72), following the same procedure as Experiment 1. All participants were adult native speakers of English. They were remunerated £2 for their contribution.

Materials and procedure

The items were the same as Experiment 1, except that we removed the additive conditions and instead included two contrastive conditions in which the connective *and* was replaced with *but*. Example materials are presented in Table 2. The rest of the manipulation (parallel vs. non-parallel) remains the same as in Experiment 1. We also re-used the 60 fillers from Experiment 1. The procedure is the same as Experiment 1. Participants took about 15 minutes to complete the experiment on average.

Results

Ten participants had less than 80% (0%-79.25%) correct answers for the comprehension questions. The reading times from these participants were therefore removed from the analysis. The other participants reached a mean of 92.29% (80%-100%), which suggests that they were reading for understanding.

We further identified outliers. We first removed any data point above 10,000ms (12 cases) or under 50ms (no case). 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 (222 cases, 4.6% of the data).

A mixed-effect linear regression was fitted to the data, including the interaction between Connective and Structure and random intercepts by item and by participant. It returned a significant main effect of Structure, with faster reading times after a parallel than a non-parallel structure (ß = -81.76, SE = 27.9, t = -2.931, $p < .01$), and a high

statistical power for this effect (84.5% [82.11, 86.69]). The effect of Connective (ß = 23.41, *SE* = 27.9, *t* = -0.839, *p* = .40) and the interaction between Connective and Structure were not significant (ß = -14.65, *SE* = 39.45, *t* = -0.371, *p* = .71). Estimated conditional means are reported in Table 2.

Discussion

This second self-paced reading study further confirmed our hypothesis regarding the facilitating effect of parallelism, with faster reading times in the parallel than non-parallel condition. However, contrary to our predictions and to previous studies (e.g. Cain & Nash, 2011), we found no difference between *and* and *but* as connectives of contrast. While caution must be taken in interpreting non-significant effects, this result raises the possibility that the heavy semantic marking of the contrastive relation through antonyms and synonyms rendered the connective redundant. In addition, *and* is not inappropriate in contrastive relations but only underspecified or ambiguous, whereas self-paced reading studies usually find effects for stronger processing difficulties, such as garden path effects (Trueswell, Tanenhaus, & Kello, 1993).

Other possible explanations for the non-significant effect of connective relate to the (in)sensitivity of the measure and to task design. While our clause-by-clause segmentation appears fine-grained enough to capture the effect of parallelism, it might be that differences between connectives and relations would appear only in smaller segments. Moreover, some comprehension questions were very simple and did not require deep processing of the coherence relation, while 50% of trials were not followed by any question, which may have made participants more passive in their reading behaviour (Stewart, Pickering, & Sanford, 2000). It could be that *and* only underwent shallow processing, so that participants did not fully commit to a specific discourse

inference, as was already observed for other types of underspecification (Pickering et al., 2006). In addition, the fillers were quite different from the stimuli (only one proper name, rarely a coherence relation), which might have made the critical trials too obvious and led to strategic reading. Finally, there were only 20 different scenarios in our materials, since each scenario was presented a second time in its opposite version (e.g. "cheap" vs. "fancy" restaurants). In Experiment 3, we attempt to address all these methodological shortcomings by using a more explicit task with more materials and different filler items.

Experiment 3: Online overt disambiguation

The third experiment aims at testing whether an explicit disambiguation task would reinforce differences between connectives, through a deeper and more active processing by participants. In this new task design, we not only measure self-paced reading times, but also disambiguation accuracy for each trial and reaction times for this disambiguation. This experiment focuses on contrastive relations, but other types of relations, including addition, are included as filler items.

Participants

Four new groups of 33 participants (132 in total, 71% female, aged 18-66) were recruited on Prolific and remunerated (£2), following the same procedure as Experiments 1-2.

Materials

For this experiment, we started from the set of 20 unique scenarios used in Experiment 2 (all contrastive items) and created 20 additional pairs, so that no scenario

would be seen twice by the same participant. The new materials were created following the exact same structure as before, with the added constraint that sentences are now split into six segments (three in each clause), as in (7). Some materials from the original batch were slightly modified in order to fit this pattern.

(7) Lisa / enjoys being / on her own / and Kurt / enjoys being / with other people.

All items are segmented in the same way:

- Region 1: S1 proper name;
- Region 2: S1 verb phrase;
- Region 3: S1 complement;
- Region 4: connective + S2 proper name;
- Region 5: S2 verb phrase (either repeated from S1 or different);
- Region 6: S2 complement, where the relation becomes disambiguated.

Four conditions were created for each item: *and* parallel, *and* non-parallel, *but* parallel, *but* non-parallel. All stimuli express a contrastive relation. In addition, we constructed 60 new fillers that follow the same structure as the critical trials and express other coherence relations: 30 consequence items (10 connected by *and*, 20 connected by *so* including five that use a parallel structure, as in (8)), 20 additive items (10 *and* parallel, 10 *also* non-parallel, as in (9)), and 10 causal items (*because*).

(8) Connor / always cooks / spicy food / so Vicky / always eats / spicy food.

(9) Andrea / is a famous / Hollywood actress. / Zach also / works in / the film industry.

Thus participants are exposed to variation across connectives (*and*, *but*, *also*, *so*, *because*) and across relations (contrast, addition, consequence, cause). The connective

and and parallelism occur in three different relations (contrast, addition, consequence). As a result, the experimental conditions (*and*, contrast, parallelism) are less likely to stand out from the fillers, and participants are confronted to a broader range of possibilities and of connective-relation combinations. This design aimed at enforcing deeper processing of the coherence relations.

Procedure

The sentences were presented segment-by-segment on the screen. Participants had to press the space bar to show the next segment, which would replace the previous one. Each trial was preceded by three crosses to indicate the beginning of the sentence. Each trial (instead of only 50% in Experiments 1 and 2) was followed by an explicit disambiguation question that used a "fill the blank" design and took up the proper names from S1 and S2, e.g. *What Connor does is … what Aaron does*. Four options were offered: different from, similar to, caused by, the reason for. They correspond to the four coherence relations included in the experiment: contrast, addition, cause and consequence, respectively. Participants had to click on their selected option.

Participants did three practice trials before starting the experiment. There was a break after every 25 trials. Materials were distributed in four counter-balanced lists of 100 trials each (40 stimuli, 60 fillers), presented to different participants so that each participant saw one version of each item. The order of presentation was fully randomized across participants. They took 17 minutes on average to complete the study.

Results

Online disambiguation task.

Answers to the disambiguation questions were coded as either correct or incorrect depending on whether they matched the semantics of the connective (additive *also*, causal *because*, resultative *so*, contrastive *but*). For *and*, which can be disambiguated in different ways depending on the context, the answers were matched with the first author's expert categorization into either additive, resultative or contrastive relations. Contrary to the previous two experiments, the questions after each trial were not binary straightforward comprehension questions but had four options to choose from and were therefore more prone to disagreement, similarly to disambiguation/annotation tasks. It is well-known that sense disambiguation for coherence relations is challenging, even between expert annotators (Spooren & Degand, 2010). In each group, at least 25 participants (out of 33) scored 80% or higher on the disambiguation questions. An additional 24 participants only scored around 60-70% accuracy, and were included in the final dataset, because of the different nature of the task compared to Experiments 1 and 2. However, three participants only reached under 60% of accuracy on the questions and were therefore removed from the data due to their extreme low scores.

Overall, 86.29% of all answers to the disambiguation questions were correct. *Also* (from filler items) reached the highest accuracy with 95.28% of correct answers, while rates for *and* vary slightly across target relations: 81.3% correct in consequence, 87.7% in addition and 89.44% in contrast. Zooming in on the contrastive trials, a mixed-effect logistic regression model was fit to the data in order to test our hypotheses regarding disambiguation accuracy, with Connective, Structure and their interaction as fixed effects, as well as random intercepts per participant and per item. It returned a significant effect of Connective (ß = -0.38217, SE = 0.14562, z = -2.624, $p < .01$), with a slightly higher accuracy of answers with *but* (92.08%) than with *and* (89.44%), as

expected. The effect of Structure was not significant (ß = -0.17756, *SE* = 0.14086, *z* = -1.261, *p* = .21), neither was the interaction between Connective and Signal (ß = -0.07373, *SE* = 0.21333, *z* = -0.346, *p* = .73). We then measured the effect of connectives and parallelism on the speed of the answers. A linear regression with the same fixed and random effects did not return any significant effect.

Self-paced reading task.

Although the experiment includes four types of relations (contrast, addition, cause and result), we include only contrastive trials in this analysis (i.e. we removed fillers). Data from the three inconsistent participants were removed. Reading times associated with incorrect answers to the disambiguation questions were also removed, given that we are interested in the processing time of specific relations: it would therefore be misleading to include data for trials that were not accurately disambiguated by participants, since they may have been associated with a different coherence relation.[2] Finally, we dealt with outliers following the same method as in Experiments 1-2: any extreme values (under 50ms or above 4500ms for any given segment of the second clause) were removed. We then excluded outliers that were 2.5 standard deviations from the participant's mean and replaced them with their cut-off value. We report on reading times for the three regions of the S2, which correspond to regions (4)-(6) in: [1] Lisa [2] enjoys being [3] on her own **[4]** and Kurt **[5]** enjoys being **[6]** with other people. Estimated means for Segments 5 and 6 are reported in Table 3.

Segment 4. The first region only contains the connective and the subject of the second clause (e.g. *and Kurt*). Parallelism is thus not relevant for this region, since the (non-)repeated structure only appears in Segment 5. The model with Connective as fixed effect and random intercepts by item and by participant returned a non-significant

effect of Connective (ß = 9.207, *SE* = 5.456, *t* = 1.688, *p* = .09), with only a very small difference between reading times for *and* (estimated mean 558ms, *SE* = 4.63) and *but* (estimated mean 569ms, *SE* = 4.57) in this region.

Segment 5. The second region contains the verb phrase, which is either an exact repetition of the first clause (parallel), or a different, non-parallel construction (e.g. *enjoys being*). The full model with Connective, Structure and their interaction as fixed effects and random intercepts by item and by participant returned a significant effect of Connective (ß = -17.806, *SE* = 6.655, *t* = -2.676, *p* < .01) and of Structure (ß = -37.476, *SE* = 6.673, *t* = -5.616, *p* < .001), with *and* and non-parallel structures taking longer to read than *but* and parallel structures, respectively. The model also returned a significant interaction (ß = 23.945, *SE* = 9.372, *t* = 2.555, *p* < .05), in which only the difference between parallel and non-parallel *and* (ß = -38.489, *SE* = 8.77765, *t* = -4.391, *p* < .001) as well as that between parallel *but* and non-parallel *and* (ß = -31.029, *SE* = 8.704, *t* = -3.565, *p* < .01) reached significance, as can be seen on Figure 1. This pattern of results shows that the facilitation effect of parallelism is observed only with *and*, as predicted.

Segment 6. The final segment is the disambiguating region, i.e. the point where the coherence relation becomes linguistically expressed by the content of the segments (e.g. *with other people*). On this region, the full model with Connective, Structure and their interaction as fixed effects and random intercepts by item and by participant returned a significant effect of Connective, with *but* read faster than *and* (ß = -57.74, *SE* = 14.5, *t* = -3.981, *p* < .001), of Structure, with parallel structures read faster than non-parallel structures (ß = -45.14, *SE* = 14.54, *t* = -3.104, *p* < .01) and a significant interaction (ß = 42.34, *SE* = 20.42, *t* = 2.073, *p* < .05). Statistical power analysis returned high power for both main effects (Connective: 97% [95.63, 97.88]; Structure: 87% [84.33, 88.65]), and low power for their interaction (52% [48.75, 55.04]). Trials

were read faster when the clauses have a parallel structure and when they were connected by *but*. The difference between parallel and non-parallel structures was significant only with *and* (ß = -48.086, *SE* = 18.325, t = -2.624, $p < .05$), not with *but*, as can be seen in Figure 2. Differences between connectives were also no longer significant when both connectives were combined with parallel structure nor when the structures are non-parallel with *but* and parallel with *and*, thus confirming that parallelism minimizes processing differences between connectives and that it only has a compensating effect for the ambiguous connective *and*.

Discussion

This experiment used a more explicit disambiguation task, more variation across relations and connectives, and more regions than Experiment 2. The data showed a main effect of connective and of parallelism on reading times, which confirms our hypotheses on the processing cost of *and* compared to *but* in contrastive relations, as well as the facilitation effect of parallelism, which compensated for the ambiguity of *and*. These results indicate that, under an explicit disambiguation task, participants are sensitive to the informativeness of connectives and of other structural signals (in our case, parallelism) in their processing of contrast. The significant interaction between connectives and parallelism confirms that signals are particularly useful when the connective (*and*) does not explicitly encode the coherence relation, whereas their role is less crucial when the connective (*but*) is already explicit enough. Our findings thus converge with Crible's (in press) corpus data and point to a processing strategy of balancing information, as already assumed in production by the Uniform Information Density hypothesis (Levy & Jaeger, 2007).

These findings, however, contrast with those of Experiments 1 and 2, where such balancing between connectives and other signals was not observed, and only parallelism sped up reading times. Several differences in the materials and task design between our experiments prevent direct comparison of results, yet it may be that sensitivity to connective ambiguity can only be observed in a more demanding, explicit disambiguation task, and not in a more natural (and more passive) reading setting. A background task (coherence judgments) was also used by Cain & Nash (2011), who first observed a processing delay for *and* compared to more specific connectives, so that our results appear to be in line with their study. In sum, connective ambiguity is a subtle yet significant factor in the processing of contrast, and has an effect when the experimental setting requires deep processing of the coherence relation.

Lastly, results from the disambiguation questions do not confirm our hypotheses on the role of parallelism in disambiguation speed and accuracy, with no significant difference between conditions. Connective ambiguity does affect accuracy levels, with more correct answers after *but* than *and*, but had no effect on reaction times. Explicit knowledge about connectives is notoriously difficult to measure due to their procedural, non-conceptual meaning (Blakemore, 2002), and participants are often insensitive to their variation in judgment tasks (Zufferey & Gygax, 2017). The objectives of this disambiguation task were to force the participants to actively process the coherence relation for all sentences in the experiment, and to make sure that they were correctly interpreting the target relations.

General discussion

We conducted three self-paced reading experiments that aimed at measuring reading times across relations (more or less complex), across connectives (more or less

ambiguous) and across structures (parallel or non-parallel). All experiments return a consistent effect of parallelism facilitating the processing of sentences, which relates to the general mechanisms of comprehension priming (e.g. Sturt et al., 2010). Our results do not support the claim that negative relations (in our case, contrast) are more complex than positive ones (here, addition), which we tentatively explain by the heavy semantic marking of both relations overriding the instructions of the connective. The ambiguity of the underspecified connective *and*, which was expected to slow down reading times, only did so in the overt disambiguation task (Experiment 3), while participants did not find it more difficult to process *and* over *but* in a natural reading task.

This study bridges two areas of research that were previously kept distinct, namely parallelism research and discourse processing. Their combination in the present study presents a number of challenges, limitations and implications for both fields. First, our results provide support for a more discourse-functional approach to parallelism and conjunctions than what is typically the case in psycholinguistics and parallelism research. In these studies, logical semantics and theoretical assumptions often dictate how a given expression or structure is to be interpreted. This was the case of Knoeferle (2014), who considered *and* as an unambiguous additive conjunction, thus excluding its (otherwise attested) uses in other relations such as contrast. In our data, there was no interaction between parallelism and connectives without an overt disambiguation task, which may suggest that *and*, when it is used as a discourse connective, does not automatically generate expectations of similarity or parallelism, but that its meaning-in-context is only determined under some pressure to explicitly identify the coherence relation at stake. Therefore, our results confirm that *and* can be interpreted as contrastive (with a processing cost; Experiment 3), and that parallelism can facilitate these contrastive inferences. Investigating comprehension at discourse level thus

requires the adoption of a polyfunctional, contextually bound approach to meaning that goes beyond monosemous linguistic descriptions.

Such an endeavour is not without its complications and limitations. One of them is the design of materials that accurately represent the target meaning/relation, and whose interpretation is as stable as possible across participants. In discourse processing perhaps more than in other fields, individuals can differ wildly in their interpretations. For instance, Zufferey and Gygax (2020) recently showed that some participants are less sensitive to the meaning of connectives, depending on their exposure to print. To cope with this issue, we operationalized the coherence relations through clear semantic relationships between clauses and, in Experiment 3, introduced systematic comprehension questions. In addition, the recruitment of large numbers of participants (130 in each experiment), facilitated by online crowdsourcing platforms, allowed us to find robust trends across a larger sampled population than what is usually done in lab-based experiments. While online data collection methods do not fully reach the precision of lab-based systems yet, they have been repeatedly shown as reliable for a number of psycholinguistic experiments (Enochson & Culbertson, 2015; Bridges, Pitiot, MacAskill & Peirce, 2020).

Beyond such methodological considerations, the present study also bears two important implications for discourse analysis and discourse processing. Firstly, our results seem to show that, under a passive reading task, addition and contrast do not differ in terms of processing cost, despite their opposite polarity (positive vs. negative). The non-significant difference between these relations in Experiment 1 instead suggests that participants rely on the semantics of the segments with equal ease in addition or contrast. In this respect, these relations seem to differ from their causal equivalents, namely cause-consequence and concession, respectively, where strong processing

differences have been repeatedly observed (Millis & Just, 1994; Xu et al., 2015). In causal relations, comprehenders have to rely on their world knowledge and on the context to draw inferences that go beyond semantic relations of similarity or contrast. It can thus be expected that causal relations will be more deeply processed and, as a result, more affected by the ambiguity of the connective and of other signals, even under a passive reading task. The distinction between causal and non-causal relations, and crucially between concession and contrast, would therefore benefit from further investigation, as it could potentially challenge discourse frameworks that treat contrast and concession as a single relation (Biber, 1999; Fraser, 1998). In other words, causality might be more important than polarity to explain differences between coherence relations, even though such a conclusion needs to be further tested.

Secondly, the results from Experiment 3 lead us to refine generic approaches to coherence relations by taking the uses of particular connectives into account. In Murray (1997), *and* is included in the additive category, along with monosemous connectives (*moreover*, *furthermore*, *also*), and results are not reported separately for each connective within a relation. Disambiguation accuracy from our Experiment 3 instead suggests that participants are able to identify contrastive uses of *and*, thus challenging Murray's (1997) categorization. In addition, accuracy rates differed across connectives within a given relation: *also* and *but* were accurately disambiguated more often than *and* as either additive or contrastive, respectively. Overall, generic claims about given coherence relations, for instance as being more or less difficult to process, should therefore be refined by taking into account the specific connective that is used, and even by including other contextual features of the segments, as we showed that structural parallelism also impacts how coherence relations are processed. Such fine-grained

approaches were already promoted by Cain and Nash (2011, p. 439) or Asr and Demberg (2016), and the present study has strived to answer their call.

The interaction between connectives and other contextual signals of coherence relations is a growing yet challenging object of study, as it requires manipulation of structural and semantic aspects of segments while controlling for their interpretation. It is, however, a promising way forward on the path to a comprehensive, multifactorial account of discourse processing. It would be fruitful to extend the present line of research to other coherence relations, other connectives and other discourse signals, and also to combine the investigation of production and comprehension.

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Footnotes

[1]This effect was found only in Knoeferle's (2014) Experiments 2 and 3, where the conjoined clauses depended on a common verb (e.g. *The policeman reported that X and Y*). In coordinated contexts between two main clauses (her Experiment 1, more similar to our materials), she found no main effect of conjunction and no interaction.

[2]We ran the same analysis of reading times on the non-filtered dataset (i.e. including incorrect answers to the disambiguation questions) and the models returned the same effects.

Table 1

Sample Materials for Experiment 1 with Predicted Conditional Means

	Example	Estimated Means (*SE*)
Additive parallel	Nick always eats in low-budget restaurants and Grace always eats in cheap places.	1,927ms (28.14)
Additive non-parallel	Nicholas goes to low-budget restaurants and Grace always eats in cheap places.	2,014ms (28.08)
Contrastive parallel	Nick always eats in expensive restaurants and Grace always eats in cheap places.	1,891ms (28.08)
Contrastive non-parallel	Nicholas goes to expensive restaurants and Grace always eats in cheap places.	1,974ms (28.12)

Table 2

Sample Materials for Experiment 2 with Predicted Conditional Means

	Example	Estimated Means (*SE*)
AND parallel	Nick always eats in low-budget restaurants and Grace always eats in fancy places.	1,782ms (29.69)
AND non-parallel	Nicholas goes to low-budget restaurants and Grace always eats in fancy places.	1,855ms (29.77)
BUT parallel	Nick always eats in low-budget restaurants but Grace always eats in fancy places.	1,784ms (29.74)
BUT non-parallel	Nicholas goes to low-budget restaurants but Grace always eats in cheap places.	1,885ms (29.72)

Table 3

Predicted Conditional Means by Segment for Experiment 3

	Segment 5 Estimated Means (*SE*)	Segment 6 Estimated Means (*SE*)
AND parallel	517ms (6.17)	801ms (12.91)
AND non-parallel	556ms (6.22)	849ms (13.00)
BUT parallel	525ms (6.09)	790ms (12.73)
BUT non-parallel	539ms (6.15)	793ms (12.85)

Figure 1. RTs across structures and connectives for Segment 5 (Experiment 3)

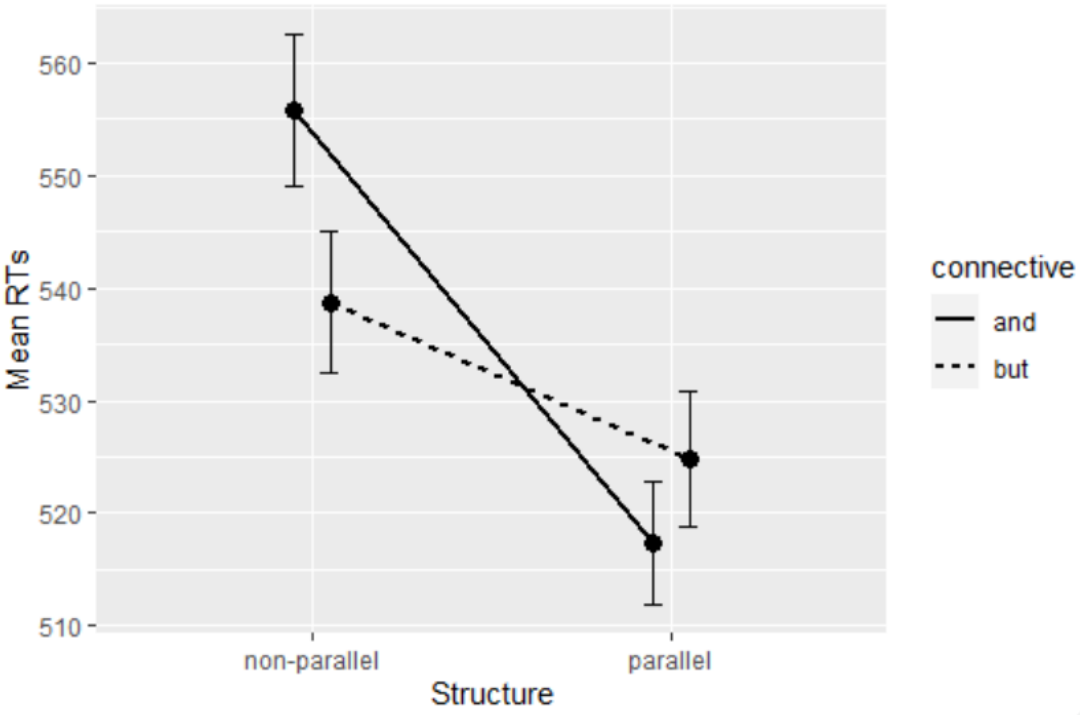

Figure 2. RTs across structures and connectives for Segment 6 (Experiment 3)