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The time-course of processing discourse connectives

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Abstract

While there is some evidence that causal discourse relations are processed incrementally, the time-course of comprehending concessive discourse markers (e.g., nevertheless) has hardly been investigated. Given that concessives are often defined as negative causals, there may be similarities between the processing of concessives and negations (e.g., a delay).

This paper investigates the time-course of processing causal versus concessive discourse markers in German within both a visual-world experiment and a reading experiment. We find that while concessive discourse markers can be processed rapidly if the context is constraining enough, there is a delay compared to causal contexts.

Keywords: Discourse connectives; prediction; concessives; incrementality; eye-tracking; visual world

Processing Discourse Relations

A large number of experiments reveals that language comprehension is generally incremental and even predictive (Marslen-Wilson, 1973; Tanenhaus & Trueswell, 1995). However, there is also evidence that incoming information across the sentence level does not always immediately update local predictions and affect global interpretation (Sanford & Garrod, 1998). It is therefore an interesting question which information from the discourse the comprehender considers, and how strongly and fast it affects comprehension and active predictions . One way to investigate this issue is to focus on the time-course of discourse connectors. Experimental evidence suggests that discourse connectors such as *because*, *therefore*, and *however* facilitate coherence building and hence comprehension: Millis & Just (1994) found that when sentences were connected by discourse markers (*because* and *although*), people were able to more successfully answer comprehension questions and to more quickly read the second sentence.

We however know much less about the time-course of processing discourse connectors. While some have argued that people only integrate them at the end of a sentence (Millis & Just, 1994), other experiments indicate that this integration happens much earlier (Traxler et al., 1997).

The experiments described in this paper examine the time-course of integrating causal connectors (e.g., therefore) versus concessive connectors (e.g., however). These are particularly interesting to compare, because concessives have sometimes been referred to as "negative causals" (König & Siemund, 2000). That means that the processing of concessives (compared to causals) may resemble the processing negation. In particular, our experiments aim to answer the following questions:

- Are causal and concessive connectives processed incrementally (possibly eliciting predictions), or with a delay?

- Do concessives elicit an active search for alternatives (as has been shown for negation, Kaup et al., 2006)?

- Regarding global interpretation, are concessive discourse relations integrated as smoothly as causal discourse relations or do they cause processing difficulties (resembling negation; Carpenter & Just, 1975; Kaup et al., 2006)?

Background

The Time-Course of Processing Connectors

Few studies have investigated the time-course of processing causals and concessives. In short discourses of two clauses, Millis & Just (1994) observed longer wrap-up times at the end of the second clause when a (causal or concessive) discourse connector was present, as compared to the same sentences without a discourse connector. Millis and Just hypothesized that a representation of the second clause was constructed without taking into account the first clause, and only later integrated with the first clause.

Millis and Just's "Connective Integration Model" of late integration of discourse connectors and earlier parts of the discourse was however refuted, at least for causal connectors. Traxler, Bybee, & Pickering (1997), for instance, found evidence for an early integration of *because* and the preceding discourse: When comparing processing of causal and diagnostic sentences, the greater difficulty in diagnostics occurred well before the end of the second clause. This indicates that processing of the second clause was affected early on by its relation to the preceding context. Further evidence for incremental processing of causal discourse relations comes from an ERP study *without* explicit connectives: Kuperberg et al. (2011) found that causally-related sentences were easier to process than sentences which were not standing in a causal relationship, revealing that causal coherence can influence the earliest stages of semantically processing incoming words.

These findings bring up a number of questions with respect to the exact time-course of processing connectives. Specifically, it is an open question in how far, and how quickly, people generate predictions taking into account discourse connectives, and how concessive connectives might differ from causals in this respect.

An interesting theory regarding predictions elicited by causal and concessive connectors comes from Murray (1995): In a series of studies, he found a greater beneficiary effect of the presence of contrastive and concessive (i.e., adversative) discourse connectors as opposed to causal and additive connectors. Murray concludes that adversative connectives create stronger expectations for the upcoming sentence than causal or additive connectors (Murray, 1995, p. 120). Murray does however not control for the ambiguity of discourse connectors, which means that his hypotheses may be taken with a grain of salt. Moreover, his findings could alternatively be accounted for by a *causality-by-default account* (Kuperberg et al., 2011; Sanders, 2005): The cause for the low facilitation for causal connectors may be that similar expectations are generated in the absence of any connector.

Concessives as Negative Causals

To date, there is very little research on the time-course of processing concessives. An early study by Townsend (1983) reveals that concessives are processed more slowly than causals and that recall is worse for concessives than for causals. These findings may suggest an interesting relationship between causals and concessives. In fact, concessives are sometimes referred to as "negative causals" (König & Siemund, 2000). Experimental studies support that causals and concessives establish the same type of relation, but are different in polarity (Louwerse, 2001; Sanders et al., 1992).

A delay of processing concessives on the one hand and defining concessives as negative causals on the other hand seems to be in line with a frequently supported theory of negation processing: Many experiments point to an account where there is a general delay in processing negation (e.g., Carpenter & Just, 1975).

Kaup et al. (2006), for instance, found in a self-paced reading study combined with a picture naming task that when processing contradictory predicates (e.g., The door is not open / closed), ,

people are first mentally simulating the positive state (open door) and only later the positive state is negated. That means people only later searched for alternatives and mentally closed the door (see also Lüdtke et al., 2008). Ferguson et al. (2008) examined the time-course of processing negation in discourse using eye-tracking in reading and ERP. Interestingly, they also found that counterfactual negated discourse information was not used incrementally but had a delayed effect on comprehension.

Other studies, on the contrary, reveal that a delay can be attenuated or completely removed when the negation is expected or pragmatically licensed (Nieuwland & Kuperberg, 2008; Dale & Duran, 2011). Staab (2007), for instance, found in a series of ERP studies that negation in discourse context was processed fast. More than that, if readers were forced to process slowly and deeply, negation was even used as a cue to rapidly anticipate how the sentence continues. These very different results suggest that the time-course of processing negation may be influenced by a number of factors such

as the kind of negated information and the discourse context. It is an interesting question how processing negative causals may enrich this picture.

Experiment 1: Visual World Study

Methods

Participants We tested 36 participants, 4 of which had to be excluded due to eye-tracking problems. Data of 32 participants (8 male, average age 26) was analyzed.

Design, Materials & Procedure We constructed 20 items, each consisting of three spoken sentences in German, and a static scene (see Example (1) and Figure 1).

(1) Marc denkt über einen kleinen [Snack nach. Er hat gerade Lust, etwas]$_{topic}$ [Süßes / Salziges zu essen]$_{category}$. [**Daher / Dennoch** holt er sich]$_{connector}$ [aus der Küche]$_{extended}$ [die appetitliche / den appetitlichen]$_{pretarget}$ [Waffel / Kuchen / Brezel / Käse]$_{target}$.
*Marc fancies a [snack. He feels like having something]$_{topic}$ [sweet]$_{category}$. [**Therefore / Nevertheless**, he gets]$_{connector}$ [from the kitchen]$_{extended}$ [the$_{[fem]/[masc]}$ delicious$_{[fem]/[masc]}$]$_{pretarget}$ [waffle / cake / pretzel / cheese]$_{target}$.*

Figure 1: Stimulus for visual world experiment.

The first sentence introduces a situation or *topic*, such as food in *Marc denkt über einen Snack nach.* ("Marc fancies a Snack"). The second sentence always identifies a *category* (e.g., sweet things), matching two of the depicted objects (waffle and cake). Two other objects in the scene belong to another category (the *counter category*, salty things: cheese and pretzel). The third sentence begins either with a *causal* (*Daher/Dennoch*) or a *concessive* (*Deswegen/Trotzdem*) connector (2-level within-participant factor), followed by subject and verb (*holt er sich*, "he gets"; connector region). This region precedes another phrase (*aus der Küche*, "from the kitchen"; extended connector region), the gender-marked pretarget noun region (e.g., *die appetitliche*), and the target noun (causal: *Waffel*, concessive: *Brezel*). Target nouns are always congruent with the preceding discourse. Visuals worlds include the four objects belonging to the category and the counter category and two distractor objects (here, cup and wire whisk), embedded in a simple scene (here, kitchen) .

Category given in Sentence 2, gender of target noun, and condition (i.e., causal/concessive) were fully counterbalanced, resulting in 8 lists. Every participant was assigned to one of the lists and saw each of the 20 items in one version only. 40 filler discourse-scene pairs were included, following the same general pattern but using a range of discourse relations and markers (e.g., *später*, "later"), making the target noun unpredictable. All items and half of the fillers were followed by a comprehension question about the target noun but referring to it by its category rather than its name (*Holt Marc sich etwas Süßes?*, "Does Marc get something sweet?"), which participants answered by button press (YES/NO). Half of the questions' correct answer was "yes", the other half "no". Order of presentation was pseudo-randomized with at least one filler in between two items. Participants were tested individually and their eye-movements were tracked. Their task was to look and listen carefully enough to reply to the comprehension questions. The experiment lasted about 30 minutes.

Predictions When the category (e.g., sweet) is mentioned, fast and incremental processing predicts participants to look more often at the two objects matching this category (waffle and cake) in both conditions.

For the third sentence, predictions for causal and concessive sentences differ: In the causal condition, people are predicted to keep looking at the category objects until the case-marked pretarget region. During the pretarget region then, fast and incremental processing predicts more looks towards the gender-congruent object, and finally, when the target is mentioned, more looks to the target. In the concessive condition, however, hypothesizing that the concessive connector is processed eagerly and incrementally predicts participants to change from looking to the category objects to looking to the two counter-category (salty) objects (pretzel and cheese), as soon as the scope of the concessive connector is clear.

In particular, the scope could be inferred and a search for alternatives could be initiated after the subject and verb following the connector (connector region). The hypothesis that the concessive connector is processed fast and incrementally, also predicts participants to start looking more frequently at the final target object during the gender-marked pretarget region. A late integration account, or a simple lexical priming account would not predict this pattern but that participants keep looking at the category objects (sweet things) until they hear the target word.

Data Analyses & Results

For eye-movement analyses, we compared inspections to the four areas of interest (AOIs): target (e.g., waffle), category competitor (sharing category with target, e.g., cake), gender competitor (sharing gender with target, e.g. pretzel), and unrelated competitor (sharing neither category nor gender with target, e.g., cheese). Four time regions were of interest: category region, connector region, extended connector region, and pretarget region. Eye-movements were analyzed using logistic regressions, entering the data into linear mixed effect models with logit-link function (from the lme4 package in R; Bates, 2005). AOI and Condition (causal/concessive) were used as a Fixed Factors and Participant and Item as random factors. Main effects were tested based on model comparison using a χ test (Baayen et al., 2008). Random slopes for Participant and Item were evaluated based on model comparison as well and included when they improved the model fit. For contrasts between levels (AOIs), we report Wald-z values and p-values as well as coefficients (β) and standard errors (SE).

Analyses reveal that in the category region, participants inspected the two objects matching this category (causal: target + category competitor; concessive: gender competitor + unrelated competitor) significantly more frequently than the counter-category objects, independent of condition (effect AOI: $\chi(1) = 49.26$, $p < .001$; no effect condition: $\chi(1) = 1.99$, $p = .16$; no interaction: $\chi(1) = 1.88$, $p = .17$). In the connector region, there was an effect of AOI ($\chi(1) = 7.78$, $p < .01$), no effect of condition ($\chi(1) = 0.26$, $p = .61$), but, importantly, an interaction ($\chi(1) = 4.17$, $p < .05$): In the causal condition, the category objects were still looked at significantly more often than the counter-category objects ($\chi(1) = 11.38$, $p < .001$); in the concessive condition, however, participants inspected the two counter-category objects just as much as the category objects ($\chi(1) = 0.30$, $p = .58$). As illustrated in Figure 2, this is due to them first looking more at the category objects, but gradually starting to look more at the counter category objects, as the scope of the concessive becomes clear. In the extended connector region then, we find significantly more looks to the objects of the counter-category objects in the concessive condition ($\chi(1) = 15.19$, $p < .001$) as well as still significantly more looks to the category objects in the causal condition ($\chi(1) = 18.64$, $p < .001$). That means that looking at the target category (i.e., category in causal and counter-category in concessives) was independent of condition in this region (effect of AOI: $\chi(1) = 33.65$, $p < .001$, no effect of condition: $\chi(1) = 0.76$, $p = .38$, and no interaction: $\chi(1) = 0.11$, $p = .74$). This reveals that the concessive marker was immediately interpreted, and that people engaged in an active search for alternatives. In the pretarget region (when shifted 200ms)[1], the target was looked at more frequently than all other objects in both conditions (effect AOI: $\chi(3) = 20.42$, $p < .001$, no effect condition: $\chi(1) = 0.01$, $p = .92$, no interaction: $\chi(3) = 0.87$, $p = .87$; effect AOI causal: $\chi(1) = 63.16$, $p < .001$; effect AOI concessive: $\chi(3) = 12.62$, $p < .01$). In the causal condition, the differences to gender competitor ($\beta = -1.11$, $SE = 0.19$, $z = -5.92$, $p < .001$) and unrelated competitor ($\beta = -1.26$, $SE = 0.19$, $z = -6.53$, $p < .001$) are significant and the difference between target and category competitor is marginally significant ($\beta = -0.32$, $SE = 0.17$, $z = -1.87$, $p = .06$).

In the concessive condition, the difference between target and category competitor, on the contrary, fails to reach signif-

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[1]This is frequently done for short eye-tracking regions in visual world studies because 200ms is known as the amount of time needed to program an eye-movement.

icance (β = -0.20, $SE = 0.17$, $z = -1.18$, $p = .24$), whereas the target was looked at significantly more often than gender competitor (β = -10.89, $SE = 0.18$, $z = -4.88$, $p < .001$) and unrelated competitor (β = -1.07, $SE = 0.19$, $z = -5.65$, $p < .001$).

Accuracies and Reaction Times for comprehension questions were analyzed the same way as eye-movements, except that we used linear regressions rather than logistic regressions for response times. While response times did not differ across conditions ($\chi(1) = 0.44$, $p = .51$), accuracy was significantly lower in the concessive condition (78%) than in the causal condition (84%; $\chi(5) = 11.17$, $p < .05$). More detailed analyses reveal that this difference was driven by the lower answer accuracy for those questions in the concessive condition in for which the correct answer was "yes".
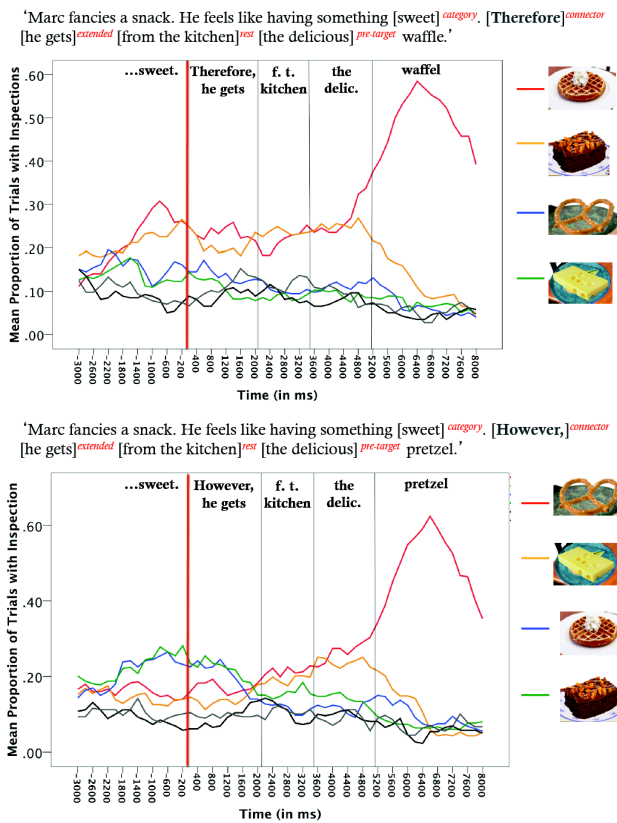
'Marc fancies a snack. He feels like having something [sweet]^{category}. [**Therefore**]^{connector} [he gets]^{extended} [from the kitchen]^{rest} [the delicious]$^{pre\text{-}target}$ waffle.'

'Marc fancies a snack. He feels like having something [sweet]^{category}. [**However,**]^{connector} [he gets]^{extended} [from the kitchen]^{rest} [the delicious]$^{pre\text{-}target}$ pretzel.'

Figure 2: Results for causal (top) and concessive (bottom) conditions.

Discussion

These results clearly reveal that both causal and concessive discourse markers were integrated rapidly into on-line comprehension and that processing the concessive led to a search for alternatives.

In the causal condition, processing was rapid and stable enough to combine with grammar information to predictively identify the target referent. In the concessive condition, there is a similar tendency but it did not reach significance. This

may mean that processing concessives is more difficult and does not allow people to rapidly take gender marking into account. The result that looks to the target category exceed looks to the other objects later in the concessive condition than the causal condition may reflect slower processing in the concessive condition. However, since, in the causal condition, the objects belonging to the target category were already looked at most before the connector region, the finding cannot be clearly interpreted.

The finding that accuracy of question answering was worse in the concessive than the causal condition (when the correct answer was "yes") might suggest that processing in the concessive condition was shallower, causing a late cognitive burden for global interpretation. An alternative possibility is that suppressing the category directly mentioned in the second sentence (e.g., sweet) in combination with having to categorize the target (e.g., pretzel - salty) might be difficult (as in *sweet... however... pretzel - ... something salty?*)

Experiment 2 evaluates whether our finding that discourse markers can be integrated rapidly, shaping predictions about upcoming words, can be replicated in a reading experiment.

Experiment 2: Reading Study

Methods

Participants   We tested 30 participants, 6 of which had to be excluded due to eye-tracking problems. Data of 24 participants (5 male, average age 24) was analyzed.

Design, Materials & Procedure   Items for Experiment 2 consist of 24 three-sentences discourses, following a similar logic as the ones of Experiment 1. However, rather than reducing the set of possible predictions by providing a picture, a more strongly constraining first sentence introducing two scenarios is employed. The second sentence makes one of these two options more salient. The third sentence begins with either a causal or a concessive marker, followed by a region which determines the focus of the concessive, a pretarget region which contains case-marking, and the target noun region (see Example 2). The target noun is not used in the preceding context. Half of the sentences are congruent (e.g., head and ears cold - therefore - hat), and half incongruent (e.g., neck cold - however - scarf), resulting in a 2(causal/concessive)x2(congruent/incongruent) within-participant design. All sentences are grammatically correct.

(2)   Lotte braucht für den Winter noch Kleidungsstücke um Kopf und Hals zu wärmen. An Kopf und Ohren friert sie besonders. **Daher / Dennoch** guckt sie als allererstes nach [einer schön warmen / einem schön warmen]$_{pretarget}$ [Mütze/Schal, die/der nicht zu bunt aussieht]$_{target}$.
Lotte needs clothes to keep her head and neck warm for the winter. Her head and ears feel particularly cold. **Therefore / However**, *she first of all looks for* [a nicely warm]$_{gender-marked\ pretarget}$ [hat / scarf that does not look too colorful]$_{target}$.

The 24 items were intermixed with 48 filler discourses, which followed the same pattern as the items but using a range of non-causal/concessive discourse markers (e.g., later, in particular). All items and half of the fillers were followed by yes/no-comprehension questions, asking about the target noun without referring to it by name (*Schaut Lotte als erstes nach einem Kleidungsstück für den Kopf?*, "Does Lotte first of all look for clothing for the head?"), answerable by button press. Half of the questions' correct answer was "yes", the other half's "no". We created 8 lists, according to the numbers of versions per item: 2(salience second sentence)x2(causal/concessive)x2(match/mismatch). Participants saw only one version of each item.

Discourses were presented on the center of the screen, divided into two parts: The first screen showed the first and second sentence and the second screen contained the target sentence. The question, if present, followed the discourse on a third screen. Reading was self-paced, controlled by button press. The order of presentation was pseudo-randomized with at least one filler in between two items. Participants were tested individually and their eyes were tracked. They were asked to read carefully to be able to correctly answer comprehension questions. The experiment lasted approximately 30 minutes.

Predictions Given our results from the first experiment, we hypothesized that people would be able to eagerly integrate discourse context and the the discourse connector to predict the target noun. This predicts a mismatch effect (as expressed in longer reading times: first pass durations, regressions, and total reading time) in the pretarget region when the grammatical gender of determiner and adjective does not match the grammatical gender of the predicted target noun. This mismatch effect is moreover predicted to continue in the target region.

Data Analyses, Results & Discussion

First pass durations, regression durations, and total reading times in the pretarget (determiner and adjective) and target (noun and final phrase) region were analyzed using linear regressions (see Experiment 1). Trials with track loss in more than one of all regions (Sentence 1, Sentence 2, discourse maker region, pretarget region, target region, question) and with reading times smaller than 50 ms were excluded from analyses.

For the causal condition, we found a consistent tendency for people to read more slowly in mismatching than matching sentences in both the pretarget and the target regions in all measures; none of these trends, however, reached significance. In the concessive condition, similar but weaker tendencies were found, but only for first pass reading times. While this could mean that discourse information cannot be integrated fast enough to give rise to prediction neither in causals nor in concessives, we considered the possibility that some of our items were not clear or constraining enough to enable readers to anticipate the target noun.

To still get an idea about the indicated difference between causal and non-causal contexts (i.e., using the causal condition as a baseline), we excluded those items for which no mismatch effect was observable in total reading times in the causal condition in the target region (i.e., when reading times were not higher for mismatches than matches, not even any time after the target noun was encountered). Based on the remaining 19 items, we found significantly longer reading times for mismatches in the pretarget region of causal sentences for all measurements (first pass $\chi(1) = 5.38, p < .05$; total time: $\chi(1) = 7.27, p < .01$; regression: $\chi(1) = 4.99, p < .05$).

However, even for these 19 predictable discourses, when the discourse relation was concessive, there was only a marginal effect of mismatch for first pass durations in the pretarget region ($\chi(1) = 3.43, p = .06$) but no further effects for the pretarget region (total time: $\chi(1) = .02, p = .89$; regression: $\chi(1) = 0.07, p = .80$) and not even in the target region (first pass $\chi(1) = 1.12, p = .29$; total time: $\chi(1) = 0.02, p = .88$; regression: $\chi(1) = 0.15, p = .70$).

For comprehension-question accuracy, there was no effect of condition (causal: 80%, concessive: 82%; $\chi(1) = 1.40, p = .24$), a marginal effect of mismatch ($\chi(1) = 3.57, p = .06$) and a significant interaction ($\chi(1) = 4.01, p < .05$): Accuracy was significantly higher for match than mismatch only for causals ($\chi(1) = 5.81, p < .05$) but not for concessives ($\chi(1) = 1.17, p = .68$). For Reaction Times, there was no effect of match ($\chi(1) = 0, p = 1$) nor condition ($\chi(1) = 0, p = 1$), and no interaction ($\chi(1) = 0.38, p = .54$).

Experiment 2 therefore indicates that, given that the discourse is really clear and constraining, in causally related sentences, readers are generally able to make predictions based on quickly integrating discourse context. In other words, if the target noun was predictable, then it was predicted rapidly (i.e., in the pretarget region). Global interpretation, as well, was influenced by the congruency of the discourse, as indicated by results from question answering accuracy. For concessives, on the contrary, there is no consistent evidence, that either of this was the case.

General Discussion

While results from Experiments 1 and 2 are not fully in line with one another, it is likely that prediction is easier with a constraining visual scene which is co-present during the entire discourse than with a linguistic context which is only read once and needs to be remembered and re-accessed. Moreover, while there was a prediction effect for concessives in the extended connector region in Experiment 1, prediction was also slower (or more slowly stable) in the concessive than the causal condition (no significant effect in the concessive case in the pretarget region). Possibly, processing concessives was simply more slowly than processing causals in both experiments.

Another possible explanation however is that the scope of the concessive is more ambiguous than the scope of causals

in experimental items of Experiment 2:

causal *Timmy wants to do A and B. A is more important. Therefore ˽*

concessive *Timmy wants to do A and B. A is more important. However ˽*

In the causal case, the causal connector can only refer to the previous sentence "A is important", hence only *A* is a sensible continuation. In the concessive case, the concessive marker might take scope either over the second sentence, in which case the prediction would be, as anticipated, *However B*. But, it is also possible for the concessive to take scope over both initial sentences, leading to a prediction *However C*, that is, Tommy goes on to do something entirely different. In that case, the space of possible predictions is wide open and cannot be expected to cause a gender mismatch effect.

For the visual world experiment, this difference in scope between causals and concessives is not an issue as the visual scene is very explicit. An interesting aspect about the hypothesis that concessive markers give rise to less specific predictions than causal markers is that it stands in apparent contrast to the hypothesis by Murray (1995) discussed earlier : Murray suggests that concessives are highly constraining while causal connectives are moderately constraining and leave more open hypotheses. We believe that Murray's and our hypotheses are not necessarily contradictory, however: While concessive markers may be less ambiguous with respect to the discourse relation they are marking (see also Asr & Demberg, 2012a,b), they may at the same time be more ambiguous with respect to the scope of their argument.

Results from Experiments 1 and 2 are generally in line with studies revealing immediate interpretation of discourse markers (e.g., Traxler et al., 1997). However, our data also supports that negating a discourse relation (i.e., via adversative markers) may cause a delay in processing, at least when a directly mentioned state of affairs needs to be rejected and its opposite needs to be both mentally accessed and found (on a scene or in memory). That means that concessive discourse markers are a type of negation that can cause processing difficulties. Moreover, Experiment 1 supports that negation can give rise to a search for alternatives (Kaup et al., 2006).

Conclusions

We investigated the time-course of processing marked causal and concessive discourse relations within two experiments. Results from a visual world experiment (Exp. 1) provide clear evidence that, at least in this highly constraining scenario, both causals and concessives can be processed incrementally and give rise to predictions. Concessives, specifically, elicit an active search for alternatives. A reading experiment (Exp. 2) confirms this finding for causals but not for concessives. Results of both experiments indicate that concessives may be more difficult to process than causals, causing a delay. In Experiment 2, difficulties with concessives may also be due to ambiguity in scope.

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