

The time course of negation integration in establishing interclausal relations

Siqi Lyu¹ (lyusqi@163.com), Chien-Jer Charles Lin²
¹University of Tartu, ²Indiana University Bloomington

Introduction. Negation processing is an effortful process. While a two-step account suggests an additional step for negation to be integrated [1], e.g., (1a) is easier to process than (1b) whereas (1d) is easier to process than (1c) (i.e., an interaction between sentence plausibility and negation), it has been argued that negation can be rapidly incorporated without extra processing costs when it is pragmatically [2] or syntactically [3] licensed, e.g., false sentences like (1c) and (1d) are always harder to process than true sentences like (1a) and (1b) (i.e., a main effect of plausibility).

An important remaining question is that most studies have focused on negation within simple sentences. Our study investigates the time course of negation integration in a larger discourse, e.g., in establishing interclausal relations. A concessive sentence like (2a) has been considered a negative counterpart of causality like (2b) [4]. In this study, we investigated how semantic cues such as concessive or causal connectives affect the processing of negation in real time.

Methods. A self-paced reading experiment (N = 52) was conducted where discourse relation (concession vs. causality), negation (affirmative vs. negative), and sentence plausibility (plausible vs. implausible) were manipulated as fixed factors. Materials were three-clause structures in Chinese, where the first two clauses (C1 and C2) formed a concessive or causal relation, followed by a third clause (C3), which was a neutral comment on the previous sentence and served as an additional region for possible carried-over effects, as shown in (3). Negation and plausibility were manipulated by the verb predicates in C2, where antonymous verb pairs (e.g., *save* vs. *delete*) were used in either their affirmative (with an aspect marker *-le*) or negative (with a negative marker *mei* 'not') form, each forming a plausible or implausible relation with C1. A norming test was administered to determine the plausible and implausible conditions (i.e., significant differences ($p < .05$) in terms of sentence acceptability), based on which 21 sets of sentences were selected for the online experiment.

Results. Linear mixed models were fitted to log-transformed reading times on the critical region (CR, i.e., verb predicates in C2) and its two subsequent regions (CR+1 and CR+2) (Figure 1). Subjects and items were included as random intercepts. At **CR**, we found a three-way interaction ($\beta = -0.17$, $t = -2.50$, $p < .05$). Follow-up tests showed a plausibility by negation interaction in causality ($\beta = -0.13$, $t = -2.63$, $p < .01$) but not in concession. The interaction in causality was driven by shorter reading time in plausible-affirmative sentences than implausible-affirmative ones but longer reading time in plausible-negative causal conditions than implausible-negative ones. At **CR+1**, we found a two-way interaction between discourse relation and plausibility ($\beta = 0.16$, $t = 2.50$, $p < .05$), with follow-up tests showing a main effect of plausibility only in concession but not in causality. At **CR+2**, we found a main effect of plausibility ($\beta = -0.23$, $t = -4.51$, $p < .001$). The plausibility effect at CR+1 and CR+2 both showed that implausible sentences took longer to read than plausible ones.

Discussion. In this study, we found an interaction between plausibility and negation in causality but a main effect of plausibility in concession. We suggest that it is due to different semantic complexities of the two discourse relations.

The observed interaction between plausibility and negation at CR in causality suggests that participants first ignored the negative marker, e.g., *not delete* in (3f) and *not save* in (3h), and only represented the verb in its positive argument as *delete* (i.e., implausible) and *save* (i.e., plausible), respectively. When processing a default cause-effect relation, participants only incorporated the overt negator at a later stage, as revealed by the main effect of plausibility at CR+2.

By contrast, the main effect of plausibility found at CR+1 and CR+2 in concession corroborates previous studies where negation is rapidly incorporated rather than take extra costs to process [2,3]. We suggest that negation is semantically licensed in a

concessive context. When processing concession, comprehenders held a negative prediction as cued by the concessive connectives and incorporated the negative expression as fast as the positive ones [5,6].

Of note is that the plausibility effect in concession did not show up until CR+1. Initial concessive clauses are processed with greater uncertainty as readers do not know which event is to be rejected until the subsequent clause has been fully interpreted [7]. The plausibility effect in concession was thus carried over to the object in C2 (i.e., CR+1), rather than immediately show up at the verb predicate (i.e., CR).

Conclusion. This study extends negation processing to a larger discourse and finds that while negation is integrated at a later stage in causal relations, it is rapidly incorporated in concession. It is suggested that semantic cues like concessive connectives play an important role in mitigating the cost of processing negation.

- (1) a. With proper equipment, scuba-diving is very safe and often good fun. (True-Affirmative)
 b. With proper equipment, scuba-diving isn't very dangerous and often good fun. (True-Negative)
 c. With proper equipment, scuba-diving is very dangerous and often good fun. (False-Affirmative)
 d. With proper equipment, scuba-diving isn't very safe and often good fun. (False-Negative)

- (2) a. Although he studied a lot, he *failed* / *didn't pass* the exam.
 b. Because he studied a lot, he *passed* the exam.

(3) Example stimuli and indication of regions

	1	2	3	4	5	6	7 (CR)	8 (CR+1)	9 (CR+2)
a. Concession-plausible-affirmative	虽然 although	小颖 Xiaoying	编辑 edit	百般小心, very careful	但是 but	还是 still	误删了 delete ASP.	文件, file	的确如此。 It's true.
b. Concession-plausible-negative	虽然 although	小颖 Xiaoying	编辑 edit	百般小心, very careful	但是 but	还是 still	没保存 not save	文件, file	的确如此。 It's true.
c. Concession-implausible-affirmative	虽然 although	小颖 Xiaoying	编辑 edit	百般小心, very careful	但是 but	还是 still	保存了 save ASP.	文件, file	的确如此。 It's true.
d. Concession-implausible-negative	虽然 although	小颖 Xiaoying	编辑 edit	百般小心, very careful	但是 but	还是 still	没误删 not delete	文件, file	的确如此。 It's true.

'Although Xiaoying was very careful in editing, she still **deleted** / **didn't save** / **saved** / **didn't delete** the file. It was true.'

e. Causality-plausible-affirmative	因为 because	小颖 Xiaoying	编辑 edit	百般小心, very careful	所以 so	最后 finally	保存了 save ASP.	文件, file	的确如此。 It's true.
f. Causality-plausible-negative	因为 because	小颖 Xiaoying	编辑 edit	百般小心, very careful	所以 so	最后 finally	没误删 not delete	文件, file	的确如此。 It's true.
g. Causality-implausible-affirmative	因为 because	小颖 Xiaoying	编辑 edit	百般小心, very careful	所以 so	最后 finally	误删了 delete ASP.	文件, file	的确如此。 It's true.
h. Causality-implausible-negative	因为 because	小颖 Xiaoying	编辑 edit	百般小心, very careful	所以 so	最后 finally	没保存 not save	文件, file	的确如此。 It's true.

'Because Xiaoying was very careful in editing, she finally **saved** / **didn't delete** / **deleted** / **didn't save** the file. It was true.'

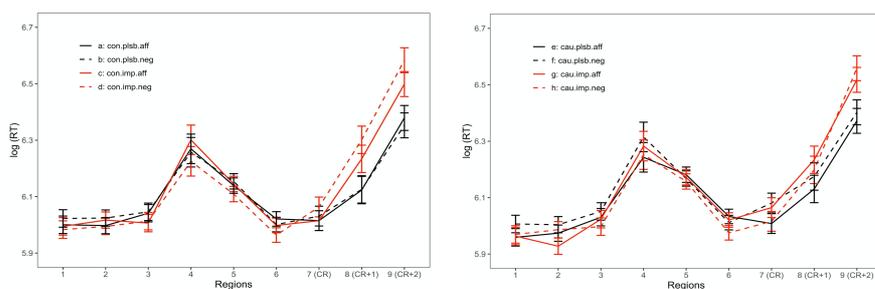


Figure 1. RT by regions. Left: concessive conditions (a)–(d); Right: causal conditions (e)–(h)

References: [1] Kaup, Lüdtke, & Zwaan. 2006. *JoP*. [2] Nieuwland & Kuperberg. 2008. *PS*. [3] Tian, Ferguson, & Breheny. 2016. *LCN*. [4] König 1991. In Zaefferer (ed.). [5] Lyu, Tu, & Lin. 2020. *DP*. [6] Morera, León, Escudero, & de Vega. 2017. *DP*. [7] Townsend & Bever. 1978. *JVLVB*.