

Does negation influence the choice of sentence continuations? Evidence from a four-choice cloze task

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Research question. People can form expectations about upcoming words based on several types of information, ranging from different linguistic properties to knowledge about events within a given context (for an overview, see Kuperberg & Jaeger, 2016). As a result of the constraining context and the high expectancy of the upcoming word, for an affirmative sentence like *The day was breezy so the boy went outside to fly a ...* the most likely continuation is *kite* (Delong et al. 2005). As of yet, little is known about how negative sentence fragments are completed. In three behavioral experiments, we investigated how negation influences the choice of continuations when used in relation to world-knowledge and semantic information.

Experiment 1. The participants' task was to continue sentences like *The child will (not) eat the___*, by pressing 1, 3, 7 or 9 on the number pad, corresponding to the position of the four words on the screen (*yoghurt, shellfish, branch, minivan*). The experiment took place in the lab and it was run in German (N=60). The procedure was controlled by *PsychoPy* (Pierce et al., 2019). The trial order of the experimental sentences as well as the location of the answer words in the displays were randomized for each participant.

Predictions. For a sentence such as *The child will eat the ...* people are expected to choose a word like *yoghurt* (expected), rather than *shellfish* (weak violation of world-knowledge), *branch* (severe violation of world-knowledge) or *minivan* (semantic violation). The *expected* answer (*yoghurt*) is predicted by a high probability situation cued by encyclopaedic knowledge (*Children eat yoghurt*), the *weak world-knowledge violation* (*shellfish*) is less likely but it can be pragmatically accommodated, while the *severe world-knowledge violation* (*branch*) is unlikely but in line with the selectional restrictions of the verb (Milburn et al., 2016). The *semantic violation* (*minivan*) is semantically incoherent and renders the sentence impossible.

In case of negative sentence fragments, different patterns of responses in the negative conditions would indicate different interpretation strategies. No differentiation between the options would indicate purely logical negation, with no influence of the plausibility or likelihood of the situation being denied. In contrast, a bias towards the expected word would indicate a preference to interpret negation as denying the most plausible positive situation, i.e. *Children usually eat yoghurt*, while a bias towards the weak world-knowledge violating word would indicate a preference to interpret negation as the description of the most plausible negative situation, i.e. *Children don't usually eat shellfish*.

Stimuli. We created 48 experimental sentences, which were further divided into three categories: (a.) the *trio* category (*The child will (not) eat the yoghurt/shellfish/branch/minivan*) which targeted combinatory effects between the agent, the verb and the patient; (b.) the *they* category (*They will (not) burn the photos/clothes/TV/rain*), meant to maximize predictive effects of verb-selectional restrictions alone; (c.) the *lexical association* category (*The farmer will (not) drive the tractor/bus/tank/chair*) where the combinatory effects of the agent and the patient were maximized.

When constructing the materials, we ran a cloze test (N=3) to select the *expected* answer. To avoid highly predictable choices, we did not use any hits from the cloze task but related words as *expected* words for the *trio* and the *they* categories. In contrast, for the *lexical association* category, we only chose as *expected* words those that obtained three hits. In other words, the *expected* answer

in the *trio* and *they* categories was cued exclusively by plausibility, whereas the *lexical association* category was cued by both predictability and plausibility.

The four answer options were controlled for *frequency* with the *Leipziger Wortschatzportal* ($F(3,141) = 1.81, p = .15$). Additionally, the experimental items were rated for plausibility ($N=12$). The *expected* answer was rated as more plausible than the *weak world-knowledge violation* ($t(11) = 14.60, p < .01$), which was rated more plausible than the *severe world-knowledge violation* ($t(11) = 10.34, p < .01$), which was rated more plausible than the *semantic violation* ($t(11) = 14.37, p < .01$).

Results. The frequency of the choices for the four words depending on polarity and type are given in Table 1. The choices were not influenced by polarity (i.e. the presence/absence of negation) ($\chi^2(3) = 4.74, p = .19$). However, there was a clear difference in frequency of the four word categories ($\chi^2(3) = 4744.4, p < .01$). The expected answer was chosen most frequently regardless of polarity, suggesting that negation is interpreted as denial of the most plausible situation. Reaction times were significantly longer in the negative than in the affirmative condition ($t(56) = 2.99, p = .004$), indicating that participants were sensitive to the difference between affirmative and negative sentence fragments when choosing continuations. However, it is not clear that participants integrated negation into sentence meaning before choosing their answers.

Experiment 2. To ensure that the participants read and integrated negation, we added 48 fillers that could only be answered correctly if negation was taken into account (*Which animals don't live in dens? sharks/foxes/rabbits/skunks*). The experiment took place online ($N=60$) and the procedure was controlled by *JsPsych* (de Leeuw, 2015). The stimuli were presented in English to English native speakers.

Results. In contrast to Experiment 1, the choices were influenced by polarity: ($\chi^2(3) = 44.17, p < .001$). Pairwise comparisons across polarity were significant for the severe world-knowledge violation ($\chi^2(1) = 4.48, p = .03$) and semantic violation ($\chi^2(1) = 37.34, p < .001$) conditions. As in Experiment 1, the frequency of the four types differed: ($\chi^2(3) = 4594.5, p < .001$). The expected answer was the most frequent choice in both the affirmative and negative conditions. This facet of the results replicated Exp. 1 even though we excluded participants who did not process negation to a sufficient degree. However, before concluding that negation is expected to deny the most plausible positive situation, we need to rule out the possibility that participants in the present paradigm were driven only by lexical properties, and not on the basis of a sentence meaning in which negation is fully integrated.

Experiment 3. In this experiment we investigated whether people's choices with respect to negation are sensitive to informativeness. To this end, we added hedges to the experimental sentences (*Of course/obviously/certainly/definitely the child will (not) eat the yoghurt/shellfish/branch/minivan*) to render the violations more plausible in the negative. If the pattern of choices changes, we can conclude that participants indeed base their choices on a representation of the sentence meaning in which negation is fully integrated. The experiment took place online ($N=64$) with English materials and the procedure was controlled by *JsPsych* (de Leeuw, 2015).

Results. As predicted, the pattern of choices changed. In addition to an overall effect of polarity ($\chi^2(3) = 472.33, p < .001$), negation influenced the frequency of all four word choices (expected ($\chi^2(1) = 141.27, p < .001$), weak world-knowledge violation ($\chi^2(1) = 29.31, p < .001$), severe world-knowledge violation ($\chi^2(1) = 105.56, p < .001$) and semantic violation ($\chi^2(1) = 196.18, p < .001$)). This indicates that negation was fully integrated into sentence meaning. In sum, negation appears to be sensitive to informativity, overriding situation plausibility.

Concluding remarks. All in all, the present results indicate that the upcoming continuations in negative sentence fragments are chosen based on criteria of plausibility when the context does not provide any additional interpretation constraints. There is evidence that negation is fully integrated in the sentence meaning, being interpreted as denial of the most plausible situation.

Table 1. Frequencies of chosen category depending on fragment polarity (aff/neg) and type (trio, they, lexical association)

Experiment	Category	Affirmative				Negative			
		Trio	They	LexAss	Total	Trio	They	LexAss	Total
Exp. 1 German	<i>Expected</i>	370	345	451	1166	352	345	444	1141
	<i>WK weak</i>	62	97	23	182	67	96	20	183
	<i>WK severe</i>	45	35	4	84	54	33	12	99
	<i>Semantic</i>	3	3	2	8	7	6	4	17
	Total	480	480	480	1440	480	480	480	1440
Exp. 2 English	<i>Expected</i>	358	349	468	1175	340	335	430	1105
	<i>WK weak</i>	93	106	8	207	82	99	17	198
	<i>WK severe</i>	25	16	2	43	35	17	13	65
	<i>Semantic</i>	4	9	2	15	23	29	20	72
	Total	480	480	480	1440	480	480	480	1440
Exp.3 Hedges	<i>Expected</i>	395	384	493	1272	236	241	262	739
	<i>WK weak</i>	74	99	9	182	110	126	65	301
	<i>WK severe</i>	32	18	3	53	86	58	80	224
	<i>Semantic</i>	11	11	7	29	80	87	105	272
	Total	512	512	512	1536	512	512	512	1536