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Priming Abstract Modal Representations in Modals with Causatives

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Abstract

Semanticists have debated the extent to which modality and causation are related in natural language. This paper aims to promote a theory in which overt causatives share core components of meaning with deontic modals. We report a sentence recall experiment that suggests that priming can be used to target the high-level semantic representations shared between two syntactically distinct linguistic expressions. Our results show that it's possible to prime the production of the deontic modal *had to* (e.g., "George *had to* go to the store"), with causative *made* (e.g., "Jane *made* George go to the store"), suggesting that the two expressions share a component of their meaning. Our results contribute to the methodological development in experimental semantics by establishing the utility of the priming effect to target meaning.

Keywords: sentence production; structural priming; sentence recall task; semantic processing, modality; causatives

Introduction

Overt causatives in English are expressions such as *made, forced, got, had, let, allow*, as shown in the example sentences in (1).

(1) a. Jane *forced/got/allowed* George to go to the store.
b. Jane *made/had/let* George go to the store.

In the literature there are various proposals for the semantics of overt causatives. There are proposals in which causatives share meaning with modals (Ilič, 2013, 2014; Privoznov, 2023; Nadathur, 2020), and there are proposals that provide a unique account of causatives, such as a force-dynamic analysis of causatives (Wolff, Song, & Driscoll, 2002; Wolff, 2007; Copley & Harley, 2015), a probabilistic analysis of causatives (Martin, 2018), and analysis of causatives using causal models (Nadathur & Lauer, 2020; Siegal, Bassel, & Hagmayer, 2021), in which the similarities between causatives and modals are not highlighted.

There's motivation for keeping the semantics of causatives and modals distinct. Syntactically, overt causatives take a small clause as argument (Pylkkanen, 2000; Pylkkänen, 2008; Bjorkman & Cowper, 2013), modals do not. Semantically, overt causatives express actuality (Lauer, 2010; Nadathur & Lauer, 2020; Nadathur, 2023a), modals do not.[1] Irrespective of the specific proposal, any semantic analysis of overt causatives must account for the fact that deontic modal interpretations (obligation and permission) are entailed ($\models$) by causative sentences, shown here with a cancellation test for entailment (Karttunen, 1971; Stalnaker, 1974; Gazdar, 1979; Chierchia & McConnell-Ginet, 2000; Simons, 2001; Abbott, 2006; Beaver, 2010; Abrusán, 2016).

(2) a. #Jane made George go to the store, but he didn't have to.
b. George had to go to the store, but no one made him go to the store.

The cancellation test in (2-a) shows that the causative sentence conveys obligation. If we try to conjoin the causative sentence with a sentence cancelling the obligation, a contradiction arises, signaling obligation is entailed by the first conjunct, as described by the entailment pattern in (3).

(3) Jane made George go to the store. $\models$
George had to go to the store.

However, the reverse does not hold. (2-b) shows that it's possible to follow up a sentence expressing deontic obligation with a sentence that cancels a causative interpretation and no contradiction arises, indicating that obligation does not entail a causative interpretation, as shown in (4). So, it appears there is an asymmetric entailment relation between overt causative sentences and deontic interpretation.

(4) George had to go to the store. $\not\models$
Someone made George go to the store.

Although there are differences between overt causatives and modals, the two expressions share some semantic properties. For example, overt causatives vary in strength, and share similar entailment patterns between strength as modals do. There are strong causatives such as *made, forced*, and weaker causatives such as *enabled, allow, let*. Moreover, as is the case with modals, strong causatives entail weaker causatives, but weaker causatives do not entail strong causatives, as

[1] Researchers have pointed out that there are cases in which certain kinds of modals can yield actuality interpretations: Bhatt (1999); Mari and Martin (2007); Piñón (2009, 2011); Hacquard (2014); Mari (2015); Vallejo (2017). Yet contrary to the actuality expressed overt causatives, actuality expressed by certain modals is only triggered in certain contexts and is not considered part of their lexical meaning, but rather the modals' meaning interacting with tense, aspect, or context.

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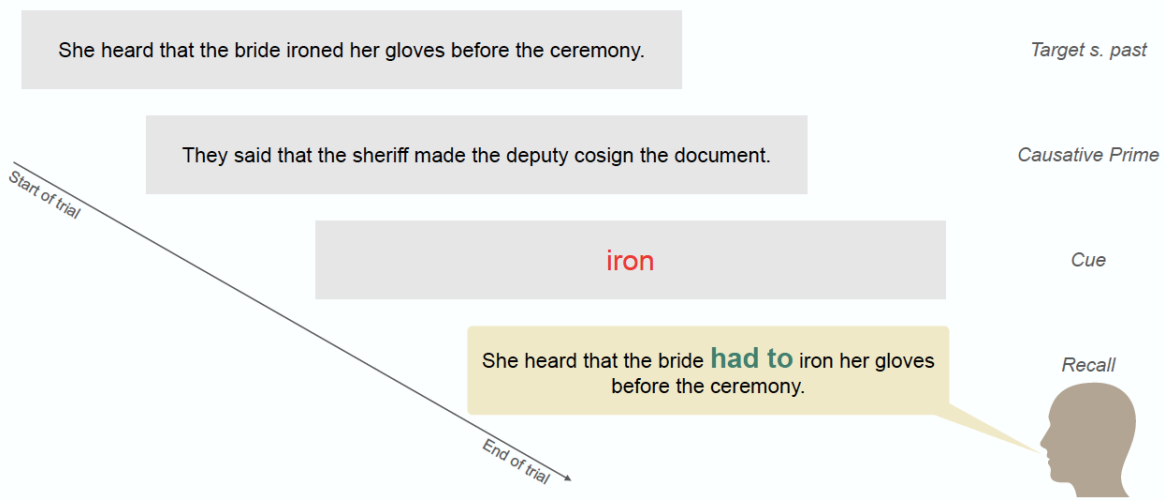


Figure 1: Graphical illustration of experimental trial with causative prime assuming *had to* bias.

Condition	Example Sentence
Modal	She said that the designer **had to** start the project over after the backlash.
Causative	He mentioned that the roommate **made** the others clean during the weekend.
Control	They heard that the actress memorized the script for the play.

Table 1: Example sentences for each stimuli condition. Grey rows mark example sentences for experimental trial conditions.

shown in (5-a) and (5-b). These entailment patterns can be confirmed via similar cancellation tests mentioned above.

(5) a. Jane made George go to the store. $\models$
Jane allowed George to go to the store.
b. Jane allowed George to go to the store. $\not\models$
Jane made George go to the store.

These observed similarities are predicted by semantic theories in which causatives and deontic modals share part of their meaning (Ilič, 2013, 2014; Privoznov, 2023). For example, Privoznov (2023) analyzes strong overt causatives such as *made* as entailing modal necessity and weak overt causatives such as *let* as entailing modal possibility. This assumption straightforwardly predicts the entailment relation between and *had to* and *made*, as well as the entailments patterns between causatives of different strengths as shown in (5-a) and (5-b). However, it should be noted that such a theory does not explain why the entailment pattern arises from overt causative sentences and deontic modality specifically, as opposed to other flavors of modality.

In this paper we evaluate whether there is empirical support for the position that causatives are best analyzed as semantically similar using priming. In particular we tested whether it's possible to prime the production of a deontic modal with an overt causative. If a priming effect is observed, it suggests that the two expressions share high-level linguistic representations, in particular, meaning, providing support for semantic theories that analyze overt causatives and deontic modals similarly.

Experiment

It's been shown that priming can target abstract semantic representations associated with a variety of semantic properties from quantifiers, number, and pragmatic enrichment (Bott & Chemla, 2016; Feiman & Snedeker, 2016), to plural ambiguities and the distributive/collective predicate contrast (Maldonado, Spector, & Chemla, 2017; Maldonado, Chemla, & Spector, 2017, 2019).

The current study tested whether people can be primed to produce deontic modal *had to* after producing a sentence containing an overt causative. We therefore assume that structural priming can target semantic representations in addition to syntactic representations (Pickering & Ferreira, 2008). As a methodology, structural priming has been successful at targeting high-level representations of linguistic expressions

(Arai, Van Gompel, & Scheepers, 2007; J. K. Bock, 1986; K. Bock, 1989; K. Bock & Loebell, 1990; Ferreira, 2003; Levelt & Kelter, 1982; Potter & Lombardi, 1998; Traxler, 2008; Sturt, Keller, & Dubey, 2010). The basic idea underlying structural priming is that speakers are more likely to repeat structures that they have previously processed. If one structure successful primes people to produce another structure, it's assumed the two structures share high-level representations.

However, structural priming doesn't only refer to the priming of syntactic structure but other kinds of linguistic structures as well. There is evidence that structural priming can target semantic structure (Branigan & Pickering, 2017; Garrod & Anderson, 1987; Meeuwissen, Roelofs, & Levelt, 2004; Raffray & Pickering, 2010) and consonant-vowel structure too (Sevald & Dell, 1994).

In the current experiment we use a sentence recall task. Sentence recall tasks have been used in a variety of sentence production studies including priming studies, though such studies aimed to target syntactic representations (Potter & Lombardi, 1998; Chang, Bock, & Goldberg, 2003; Ferreira, 2003; Momma, 2022). In the current study we show that it's possible to use the sentence recall task to target high-level semantic representations shared between two syntactically distinct structures.

Method

Participants We recruited 48 participants (mean age = 42) via Prolific for web-based research and were paid $10.00 per hour for their participation. All participants were native English speaking monolinguals from North America and gave explicit consent to participate. Participants who failed to recall the target sentence in more than 50% of experimental trials were excluded and replaced. Four participants were excluded and replaced due to technical issues concerning their audio files saving to online storage.

Materials and Procedure We designed a sentence recall task using PCIbex (Zehr & Schwarz, 2018). In each trial of a sentence recall task, participants are asked to read aloud and memorize two sentences, one of which they are prompted to recall later during the recall period after being provided with a cue. This cue is generally a word or phrase that appeared in one of the two previous sentences.

In the current study, all stimuli sentences appeared in one of three conditions: a sentence containing *had to* (modal condition), a sentence containing *made* (causative condition), or a sentence in the simple past (control condition). Filler trials contained modal, causative, and control sentences. Experimental trials contained only causative and control sentences. For consistency, all verbs, aside from modals and causatives, were eventive predicates so as to avoid the potential interaction when processing causative sentences with stative predicates (Maienborn & Herdtfelder, 2017). Moreover, all external and internal arguments were individuals in order to control the role of animacy, which is known to play a role in the interpretation of causatives (Corrigan, 1988; Scholl & Tremoulet, 2000; Seong, 2004; Copley, 2018; Heidinger & Huyghe, 2024). All sentences were embedded under verbs of saying, *she/he/they heard, said, mentioned*, for added difficulty following the results of a previous pilot study, which lacked this feature.

The experiment consisted of 72 total trials: 24 experimental trials and 48 filler trials. Of the 72 total trials, participants were asked to read aloud and memorize a sentence containing *had to* in 36 trials, half of the total number of trials. In this way participants were biased to produce *had to* during the recall period. In filler trials participants were asked to recall sentences in all conditions and order (first sentence or second sentence), which crucially included sentences containing *had to*. Experimental trials had the following structure: the first sentence was the Target and appeared in the simple past (control), the second sentence was the Prime and either contained *made* (n=12) or was in the simple past (n=12), and participants were prompted to recall the Target sentence. This means we expected participants to insert *had to* for both prime conditions during the recall period. We measured the difference between *had to* insertion given a causative prime versus a control prime.

The recall period was indicated by a cue in red. This cue was an uninflected form of a verb that appeared embedded in one of the two previous sentences, though was never *had to*, *made*, nor the embedding verb of saying. For sentences in the simple past such verb would be inflected for the past tense, while in causative and modal sentences such a verb would be an infinitive. Thus, the cue was presented uninflected in order to provide a neutral prompt for all sentence conditions. Audio was automatically recorded at the start of the recall period and stopped once the participant advanced to the subsequent trial.

Example sentences for each condition are shown in Table 1. Grey rows mark the conditions of stimuli in experimental trials. All trials were counterbalanced using the Latin square design which resulted in two item lists distributed equally over the 48 participants. Item set order was held constant across participants but there was within participant variation via item lists.

Each experimental trial proceeded as follows. Participants were presented with a screen containing the Target sentence of which they were asked to read aloud and memorize. They were able to spend up to 5000ms on the screen or else were taken to the next screen automatically at the 5000ms mark. If the participant produced the sentence in under 5000ms they were able to move to the next screen by hitting the space bar. There was a time minimum of 1000ms required to spend on each screen. Screens were separated by a blank screen (not depicted in the graphical illustration in Figure 1). Participants then repeated the process when presented with the Prime sentence. After producing the Target and Prime sentences, participants were presented with a cue, prompting them to recall the Target sentence. Similar to the previous screens, participants who produced the recall sentence in under 5000ms

could continue to the next trial by hitting the space bar. Those who did not, had up to 5000ms to produce the recall sentence or else were automatically taken to the next trial. Figure 1 shows an illustration of an experimental trial with a causative prime and assuming the *had to* bias.

Scoring and Analysis All recalled responses for experimental trials were analyzed. Audio stimuli were annotated manually. Recalled responses in which *had to* was inserted were scored with 1, or 0 otherwise. Additionally, we noted whether an expression other than *had to* was inserted during recall, but those responses were coded as 0.

All the statistical analyses were conducted using R (R Core Team, 2022) and the `lme4` package (Bates, Mächler, Bolker, & Walker, 2015). We performed a generalized linear mixed model with prime type (causative vs. simple past) as fixed effects and participants and items as random effects. The random effects structure was maximum in the sense of Barr, Levy, Scheepers, and Tily (2013). In this model, the dependent variable was the presence or absence of *had to*. The random effects of the initial model included by-participant and by-item random intercepts, as well as by-participant and by-item random slopes for prime type. However, due to convergence failure, the final model did not include by-participant random slope for prime type.

Results

We found that during the recall period, participants inserted *had to* after a control prime 41.49% of the time and they inserted *had to* after a causative prime 47.39% of the time, a 5.9% difference. This shows that because participants read and produced *had to* in many of our filler sentences (the *had to* bias), they often erroneously inserted *had to* despite *had to* not being present in the original Target sentence. However, crucially, people were more likely to insert *had to* given a causative prime, than a control prime. The *had to* insertion rates for each prime type are plotted with 95% confidence intervals in Figure 2. We found that the rate at which participants inserted *had to* after producing *made* sentence was significantly higher than after producing a control sentence (β = -.40, SE = 0.19, z = -2.09, p = 0.04). Note that in a prior study we received the same statistical pattern, though the prior study lacked the sufficient statistical power and yielded only marginal significance.

46 out of 48 participants inserted *had to* in some experimental trial and the *had to* bias is also responsible for the the comparatively high percentage of *had to*-insertion for both conditions. This shows that participants did not veridically reproduce the original target sentences and suggests that they reconstruct sentences. Because we intended the recall of Target sentences to be difficult in order to encourage participants to make mistakes, participants of course failed to accurately recall other parts of original Target sentences besides the phantom *had to*. Such common errors included forgetting the subject of the sentence, or confusing it with the subject that occurred in a previous trial; omitting the embedding verb of saying and its subject; and omitting the prepositional phrase at the end of the sentence.

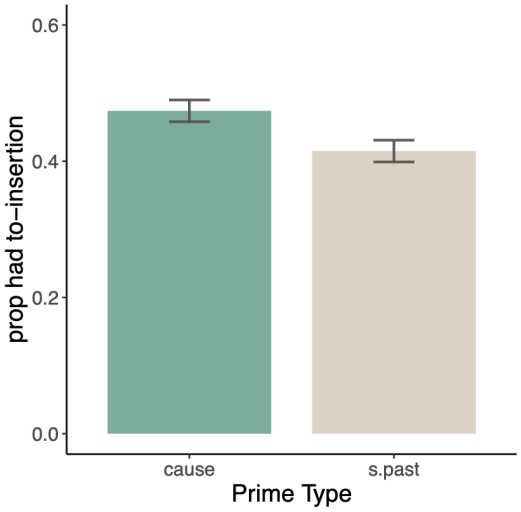


Figure 2: *Had to* insertion given prime type.

As well as omitting components of the Target sentence, participants also inserted expressions other than *had to* during the recall period. The most common non-*had to* insertion error was *made* (e.g., *They **made** the girl finish her homework before going out*), which was produced 27 times across 18 participants. This expected considering the insertion of *made* overwhelmingly occurred after a causative prime. If we assume that people are more likely to repeat structures that they have previously processed, it's possible that this observation is the result of recency effects due to participants having just produced a causative sentence in the previous screen. However, this observation is somewhat surprising given the fact that causative sentences require an internal argument (*They said that the sheriff made **the deputy** cosign the document*) and the original Target sentence that was in the simple past lacked an internal argument. This means that in order to successfully insert *made* during recall, participants had to additionally insert an argument that did not occur in the original Target sentence. This additional insertion was often the subject of the embedding verb of saying, e.g., *she, he, they*. For example, if the original Target sentence was, *They said that the girl finished her homework before going out*, the recalled sentence was reconstructed as, *They made the girl finish her homework before going out*.

It's known that similar lexical items can be primed during production (Dell & Ferreira, 2016; Ferreira, 2003; Levelt & Kelter, 1982), which explains the fact that the second most common erroneous insertion was the lexically similar past perfect *had*, e.g., *The family **had** purchased groceries for the student*, which occurred 13 times across 8 participants. Relatedly then, it is not surprising that there were also insertions of causative *had* (*The had the girl finish her homework*), which is both lexically similar to modal *had to* and semantically and syntactically similar to *made* (Bjorkman & Cowper,

2013; Palucci, 2023).

A further observation is that participants inserted expressions which have been analyzed as modal and or causal in the literature, and so are semantically similar to modal *had to*. Of these modal expressions the most commonly inserted was *would*, e.g., *They heard that the ballerina **would** pay for physical therapy after the fall*. Note that this insertion of *would* is what is called the "future in past" use of *would*, which contrasts with the counterfactual use of *would* (Asher & McCready, 2007; Arregui, 2009; Condoravdi, 2003; Kratzer, 2012). Unlike the counterfactual *would*, the "future in past" interpretation conveys actuality. There were insertions of *could*, e.g., *They said he **could** dodge the tree* (Bhatt, 1999; Hacquard, 2009, 2010b, 2010a; Kratzer, 1981). There were also insertions of implicative *tried to* and *managed to*, e.g., *The troublemaker **tried to** avoid the principal in the hallway* (Baglini & Francez, 2016; Heim, 1992; Nadathur, 2023a, 2023b), as well as insertions of future *will*, e.g., *He mentioned that the politician **will** resign after the scandal* (Cariani & Santorio, 2018; Cariani, 2021; Klecha, 2014; Matthewson, Todorovič, & Schwan, 2022). Lastly, there were other non-modal inserted expressions, though far fewer, such as *remembered*.

General Discussion

Priming effects produced with the sentence recall task have served as evidence of lexical boost (also called lexical persistence: the idea that a linguistic expression can prime a lexically similar expression) (Ferreira, 2003; Dell & Ferreira, 2016; Levelt & Kelter, 1982), as well as evidence of shared syntactic similarities between linguistic expressions (Chang et al., 2003; Ferreira, 2003; Momma, 2022; Potter & Lombardi, 1998). The priming effect reported here is novel since it seems to have resulted neither from lexical boost nor the syntactic similarity of the expressions. As previously mentioned, *had to* and *made* are syntactically dissimilar: *made* requires an external argument and takes a small clause as argument, while *had to* does not. Additionally, the two expressions are lexically dissimilar, so it is unlikely the effect is due to lexical boost. It is for these reasons we consider the effect to be the result of the semantic similarity between *had to* and *made*. This conclusion is further supported by the non-*had to* expressions that were inserted during the recall period, a majority of which have been given a modal and/or causal semantics.

We take the observed effect to support the claim that *had to* and *made* share a core component of their meaning. However, crucially the results reported here cannot be used to tease apart the various semantic proposals which treat *had to* and *made* similarly. Our results suggest that the two expressions share some component of their meaning but they cannot be used to endorse a particular unified theory over another. Further, carefully designed, studies are necessary in order to do so.

We've mentioned that the kind of priming effect reported here is unlike previous priming effects that were produced as a result of a sentence recall task in that it seems to be a result of the semantic representations associated with the two expressions. Although there are indeed syntactic differences between *had to* and *made*, it's possible to interpret the priming effect as a result of syntactic structural priming in addition to mere semantic structural priming depending on one's syntactic analysis of modal material. For example, say we assume a Kratzerian modal analysis of overt causatives as was done in Privoznov (2023). According to the analysis, overt causatives make use of a modal base and ordering source. In the literature we find various proposals for the syntactic status of a modal's modal base and ordering source. Some assume that both ingredients are contextual parameters that restrict the interpretation function of the modal when not overt (formally, $[\![\textbf{modal}]\!]^{b,o}$ or some variant of variables; *b,o* are used here for transparency) (Kratzer, 1981, 1991). Others propose that the modal base and the ordering source compose via the syntax as covert restrictors which occur within the modal phrase (formally, $[_{ModP}$[ORD-SRC] $[_{ModP}$ [BASE] [**modal**]]]) (Hacquard, 2010b, 2010a; von Fintel & Heim, 2011). If we assume this later view, it's possible to argue that the observed priming effect is targeting both semantic and syntactic structure. Though of course follow up studies are necessary in order to determine whether the priming is targeting such unpronounced pronouns as opposed to more general pragmatic material.

We introduced the relationship between deontic modals and overt causatives by showing that there exists an asymmetric entailment between the two: overt causatives entail deontic interpretation, but not the reverse. A question one might have is whether we can interpret our priming effect to be a result of priming targeting that particular asymmetric entailment. The answer is no. Again, our results suggest that the two expressions merely share some component of their meaning. In order to know whether the sentence recall task can be used to target entailment patterns between types of sentences follow-up studies are necessary. For example, it would be informative to run a very similar study where the priming bias is flipped such that participants have to produce many causative *made* sentences thereby producing a *made* bias. We could then test the difference between the rate of *made* insertion given a modal *had to* prime and a control prime. If we observe a priming effect, it would suggest that what priming is targeting is not the semantic structure responsible for the asymmetric entailment, but perhaps instead some more general association between the two expressions.

One possible criticism of the current study is the number of participants given the small size of the priming effect. To acknowledge this concern, we've conducted a power analysis using `simr` to measure the probability of successfully finding an effect more than 80% of the time in order to calculate the appropriate number of participants for the current type of study. Calculations were based on the current priming effect and experimental design, e.g., number of total trials, number

of experimental trials, and number of conditions. The power analysis shows that given the 72 trial design, there should be 117 participants in order to reach the 80% probability of reliably detecting the predicted priming effect (Brysbaert & Stevens, 2018; Brysbaert, 2019). Future studies will take this analysis into consideration.

Lastly, future follow-up studies will additionally take into account the structure of control sentences.[2] In the current study, the control sentences are embedded simple past sentences, e.g., *They heard that the actress* ***memorized*** *the script for the play.* It could be that the priming effect is a result of syntactic complexity rather than specific semantic structure associated with *had to* and *made*. Both deontic modals and overt causatives embed clauses: in the former an infinitival clause, and in the latter a small clause. Simple past sentences lack this extra syntactic structure. Perhaps people are primed to produce *had to* more so after a causative prime because both kinds of sentences are syntactically more complex than the control sentences. To address this, the control sentences in future studies will contain embedding, non-modal, predicates such as, *saw, remembered*, e.g., *They heard that the actress* ***remembered*** *to memorize the script for the play.*

Conclusion

Our results show that abstract semantic representations can be primed using the standard psycholinguistic method and contribute to the methodological and theoretical progress of understanding semantic processing and its effect on language production.

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