# A pilot study: Affect and grammatical anomaly in discourse*

VEENA DWIVEDI
*Brock University*

**Abstract:** We investigated whether differences in emotional temperament ('dispositional affect') would influence question-response accuracy rates for sentences containing modal auxiliaries. Modal sentences were embedded in contexts that were either hypothetical or factual (control). Modal auxiliaries either required clauses to restrict their interpretation ('dependent modals', *might/would*) or did not ('independent modals' *must/should*) (Stump 1985). 49 participants read two-sentence discourses followed by superficial true/false descriptive statements, e.g., *The art collector is admiring the statue*. *It would cost thousands of dollars*. Statement: *The art collector is appreciating the statue.* 1) True 2) False. We replicated previous work showing a cost for dependent modals when embedded in factual vs. hypothetical contexts. Moreover, low positive affect individuals were more accurate responding to independent vs. dependent modal sentences, regardless of context type. We interpret these findings as a facilitation effect for low positive affect individuals, who prefer simpler structures for task requirements.

**Keywords:** dispositional affect, modal auxiliaries, PANAS, sentence processing, question response accuracy

## 1 Introduction

In recent work, we have shown that the language comprehension system is not independent of the affective system in the mind/brain. Recent Event-Related Potential (ERP) work in our lab (Selvanayagam et al. 2020; Dwivedi 2020; Dwivedi & Selvanayagam 2021; Selvanayagam et al. 2019) has shown that neural responses to sentences differed according to dispositional affect scores as measured by the Positive and Negative Affective Schedule ("PANAS", Watson et al. 1988). Other ERP language studies have also found correlations between emotional mood (via mood induction procedures) and ERP components to sentences (see Chwilla et al. 2011; Federmeier et al. 2001; Vissers et al. 2010, 2013).

* Dear Hotze: We are a long, long way from sitting in class at UMass (not to mention our semantics circle club!). You heard the earliest versions of my ideas on modal subordination sentence processing during seminar – and at my kitchen table. Thanks for your comments back then and hope you enjoy the 21st century version! Happy Birthday. Contact info: vdwivedi@brocku.ca

These language specific findings corroborate work found in other cognitive domains (e.g., attention, MacLean et al. 2010; visual cognition: Schmitz et al. 2009), as well as cognitive processing in general (Huntsinger & Isbell 2014) regarding the role of affect.

Work from our lab suggests, at first blush, that the positive affective system is associated with the structural component of language. In Selvanayagam et al. (2019), we conducted an ERP dual-task study examining quantifier scope ambiguous sentences. Participants had to press either '1' or '2' at the presentation of a word in blue font on the computer screen, to indicate whether one or two words were presented. Sentence types were of the form *Every/The kid climbed a/the tree/trees*. The original hypothesis (Dwivedi & Gibson 2017; see Patson & Warren 2010) was that sentence interpretation effects would interfere with task requirements. That is, we expected interference effects when the (plural) word *trees* required a '1' button press when it happened to be the only word on the screen. At first, we wanted to know whether this potential difficulty would be mirrored at *tree* when it might be interpreted as covertly plural in quantifier scope ambiguous sentences (see Dwivedi & Gibson for discussion of results). When this work was followed up with an investigation with dispositional affect, we found P300 effects at *tree(s)* for all button-press conditions; this ERP component is known to be elicited in dual task studies. Interestingly, we observed that the sentence with the least amount of information relevant to the task, *The kid climbed the tree,* showed smaller ERP responses for low positive affect individuals (resulting in a larger P300 effect overall). We described this negative correlation between positive affect and P300 ERP amplitude differences in terms of individuals' motivation for sentence meaning interpretation. We speculated that rather than deeply attend to the meaning of the sentences, low positive affect individuals were primarily concerned with task requirements (and grammatical information relevant for the task).

In other work (Selvanayagam et al. 2020; Dwivedi 2020), we found high positive affect individuals showed larger P600 effects (Hagoort et al. 1993; Osterhout & Holcomb 1992). This ERP component was found in response to classic reduced relative clause sentences such as *The broker planned/persuaded *to conceal the transaction *was sent to jail*; (frontal) P600 effects were elicited at *was*. In that experiment, every critical sentence was followed by comprehension questions, such as: *Was the broker concealed/persuaded?* 1) Yes 2) No. Larger P600 effects were found for high positive vs. low positive individuals. We hypothesized that high positive affect individuals would be more motivated to revise

sentences that exhibited errors, whereas low positive affect individuals would not. This fits well with the theoretical notion of the P600 component as an index of syntactic revision (Kaan & Swaab 2003).

Together these results suggest that the positive affect system is sensitive to information that is grammatically relevant for task requirements.

We decided to explore this idea further by investigating another grammatical effect in language, now involving modal auxiliaries in discourse. In previous work, we examined grammatical requirements across discourse (as dictated by the semantic component) and observed an empirical contrast between sentences with *would* vs. *should* modal auxiliaries. That is, whereas modal auxiliaries such as *would* require a non-factual restrictor to be interpreted, modals such as *should* do not. This grammatical contrast was observed empirically in a self-paced reading study (Dwivedi 1996). That is, increased reading times were associated with sentences containing *would* that were preceded by factual (control) context sentences which were incongruent with the modal's requirements, e.g., *My friend's business will hire a new salesperson. The position would be open in May*. In contrast, ease of processing was observed when the previous context sentence was hypothetical (and therefore congruent with grammatical expectations), as in: *Maybe my friend's business will hire a new salesperson. The position would be open in May*. This contrast regarding different context types (control vs. hypothetical) was not observed for *should* sentences, e.g., *Kevin will try to find a date for the party. He should try a dating service* vs. *Perhaps Kevin will try to find a date for the party. He should try a dating service*. In that work, the contrast between *would* and *should* sentences was attributed to the idea that *would* requires an "if-clause" type of an antecedent to be interpreted (Stump 1985). That is, the meaning of the previous *would* discourse is something like, *Maybe my friend's business will hire a new salesperson, and [if that is the case, then] the position would be open in May* (Roberts 1996). No such 'if-clause' type of restrictor is necessary for the interpretation of sentences containing *should*. We later followed up on this work using ERP methods (Dwivedi et al. 2010; Dwivedi et al. 2006). Interestingly, when the grammatical requirements were not met in control contexts, a 'semantic' P600 effect emerged. We argued that this ERP effect, typically associated with morpho-syntactic anomaly and/or garden-path sentence types (Hagoort et al. 1993; Osterhout & Holcomb 1992), was indexing a grammatical requirement not being met during interpretation. This was among the first

papers to show, using ERPs, that structural effects could be observed using formal semantic constructs.

In the present work, we followed up on these previous modal auxiliary experiments by examining whether a similar grammatical contrast would be observed when we expanded the modal types to also include *might* vs. *must.* That is, like epistemic *would*, the possibility modal *might* also requires a non-factual restrictor for interpretation, in contrast to *should* and *must* (Stump 1985). Thus, we examined question-response accuracy rates after two-sentence discourses, where the context sentence was either factual (control) or hypothetical, and the continuation sentence contained one of two modal types: modals that were dependent on context for interpretation, 'dependent' *might*, *would* vs. 'independent' modals that were not, *must, should.*

We tested two sets of hypotheses. First, we hypothesized that we would replicate previous findings, such that empirical contrasts would be observed for dependent modal sentences embedded in control vs. hypothetical contexts. No such contrast was expected for independent modal sentences. That is, we expected higher accuracy rates when dependent modal sentences were embedded in contexts that were congruent with grammatical expectations, where no such difference for independent modals was expected. Next, regarding affect: given that we have indicated that dependent vs. independent modals have different requirements dictated by the grammatical component, we expected that positive affect scores should correlate with question-response accuracy rates. It could be the case, following our P600 results with reduced relatives (Dwivedi 2020), that high positive affect individuals are more sensitive to grammatical contrasts found for dependent modals. If so, a negative correlation is expected for positive affect and dependent modal sentences, where high positive affect individuals would perform more poorly when grammatical expectations were unmet in control contexts. Thus, these individuals were expected to show lower accuracy rates for *might, would* conditions when embedded in control vs. hypothetical contexts. On the other hand, based on our quantifier scope study (Selvanayagam et al. 2019), it could be the case that a negative correlation would be found for independent modals, when these were embedded in factual (control) contexts. That is, low positive affect individuals would be more accurate at *must, should* conditions when these are embedded in control contexts, since these discourses would have the least amount of grammatical structure and information. As such, the form of these discourses would be congruent with low positive affect

individuals' processing preferences, resulting in higher question response accuracy rates.

## 2 Materials and methods

### 2.1 Ethics statement

This study received ethics approval from the Brock University Social Science Research Ethics Board (SREB) prior to the commencement of the experiment (REB 16-179). Written, informed consent was received from all participants prior to their participation in the experiment.

### 2.2 Participants

Forty-nine right-handed native speakers of English (45 female, mean age 19.0 years, range 18 to 25 years). were recruited via the Brock University SONA participant pool and posters; participants were given partial course credit or were paid $10 (if not eligible for course credit).

**Table 1:** Examples of different modal stimuli conditions with true/false questions

| | Modal Type | |
|---|---|---|
| | Independent | Dependent |
| Hypothetical context | S1: For all we know, the forester is looking for a hibernating bear.<br>S2: It should rise after the snow melts.<br>*It's possible that the forester is looking for an old growth forest.*<br>1) True **2) False** | S1: The advertiser is conceiving of a possible campaign.<br>S2: It would turn around the company<br>*The advertiser is thinking about a career change.*<br>1) True **2) False** |
| Control context | S1: The technician is installing an antenna.<br>S2: It must supply a clear signal.<br>*The technician is erecting an antenna.*<br>1) False **2) True** | S1: The firemen are examining the ladder.<br>S2: It might rise from the back of the trunk.<br>*The firemen are inspecting the ladder.*<br>**1) True** 2) False |

### 2.3 Materials

Each experimental trial consisted of two sentences followed by a statement requiring a true/false response. The first sentence was the context sentence (Sentence 1, S1), which was either hypothetical (i.e., non-factual) or control (i.e., factual). This was followed by a continuation sentence (Sentence 2, S2), which contained one of four modal auxiliaries: those requiring restrictive clauses for interpretation (*might, would*) vs. those that do not (*must, should*). The former modal auxiliaries are dependent on context for interpretation, whereas the latter are not (independent). Sentences were adapted from (Dwivedi et al. 2006). Thus, the factorial combination of context type (control vs. hypothetical) and continuation sentence type (independent vs. dependent modal) yielded four conditions, see Table 1. There were 16 items in each condition, where half of each condition used either *might/would* or *must/should*. As this was a pilot study, stimuli length was not controlled for, and each cell had a different sentence type.

Hypothetical context sentences differed from control contexts in that they contained markers of non-factual mood (such as a modal adverb *possibly, likely, perhaps*, etc. and/or a non-factive propositional attitude verb such as *consider, muse, wonder*, etc.). In addition, the context sentence also used a verb of creation (such as *paint, bake, write*) to further bias for a non-specific reading of the indefinite noun phrase (NP) object. The control (factual) context sentences did not contain modal adverbs or non-factive propositional attitude verbs and used verbs of using (such as *read, show, enjoy*).

All 64 stimuli were followed by a statement requiring a True/False response; there were an equal number of True/False responses across trials and the position of True/False on the screen was also counterbalanced.

Four lists were created to ensure that the conditions were counterbalanced as per Latin square design. The 64 experimental items were combined with 24 stimuli from an unrelated experiment (see Dwivedi 2013), and 100 fillers, for a total of 188 items per list. All stimuli were followed by forced choice questions or true/false statements. Two buttons (labeled as "1" and "2") were designated for answer selection. An example filler stimulus/question pair is shown in below:

(1) S1: Because of the thunderstorm, Lara had trouble sleeping.
S2: She felt terrible the next day.
Q: Did Lara sleep well?

1) Yes 2) No

Participants pressed the button that corresponded to the answer on the screen. Answers were counterbalanced such that equal numbers of correct answers were displayed on the right and left side of the screen.

### 2.4 Procedure

Upon arrival for the experimental session, participants were given three short written questionnaires to complete (in counterbalanced order) regarding (i) reading habits, (ii) a handedness inventory (Briggs & Nebes 1975), and (iii) the PANAS (Watson et al. 1988) before the start of the self-paced reading study. Before starting the experiment, participants practiced on a short list of items to familiarize themselves with task requirements. The study used a moving window display (Just et al. 1982), presented via E-prime software. Questions were presented in their entirety with potential answers on the same screen, after participants has read the critical sentence. Participants controlled the timing of the presentation of the question, and upon answering the question, the next stimulus appeared after 1200 milliseconds.

The order of sentence presentation was randomized per participant by E-Prime software. A 19" widescreen Dell LCD monitor was approximately 18–24 inches from the participant, level with the participant's point of view.

Participant responses were recorded via a PSTnet serial response button box. The experiment lasted approximately 30 minutes, and participants were debriefed after the session as to the nature of the experiment.

## 3 Results

Given that this was a pilot study, length of sentences was not controlled for. As such, measures collected for sentence reading times are not of interest here and will not be described.

We focus on question-answer responses only.

### 3.1 Filler comprehension questions

Comprehension rates for questions at filler conditions were at ceiling, 96.54% (*SD* = 3.52%), and contrasted with the overall accuracy rate for stimuli with modals 92.92% (*SD* = 3.80%). A paired samples *t*-test

revealed significant difference between these accuracy rates, indicating a level of difficulty with sentences with modal auxiliaries; $t$ (48) = -6.04, $p < .001$, $d$ = -0.86.

### 3.2 Experimental trial comprehension questions

Results for accuracy rates (%) for independent modals (*must, should*) revealed that control contexts ($M$ = 91.96%, $SD$ = 5.71%) were responded to less accurately than hypothetical contexts ($M$ = 94.13%, $SD$ = 6.17%), although this did not reach significance, $t$ (48) = -1.97, $p$ = .055, $d$ = -.28. In contrast, dependent modals (*might, would*) revealed a strong difference (as indicated via Cohen's $d$), where control contexts ($M$ = 90.82%, $SD$ = 7.77%) were responded to at a significantly lower rate vs. hypothetical contexts ($M$ = 94.77%, $SD$ = 5.16%), $t$ (48) = -3.40, $p < .001$, $d$ = -.49.

### 3.3 Correlational analyses

Positive Affect (PA) scores ranged from 17 to 41 ($M$ = 30.7, $SD$ = 5.7); Negative Affect (NA) scores ranged from 11 to 43 ($M$ = 19.6, $SD$ = 6.1).[1] Table 2 shows Pearson $r$ correlations with Positive Affect scores and question-response accuracy rates in each condition

**Table 2:** Pearson correlations for question-response accuracy rates between PA vs. hypothetical/control and independent/dependent modals

| | | Control: Independent | Hypothetical: Independent | Hypothetical: Dependent | Control: Dependent |
|---|---|---|---|---|---|
| PA | *r* | -.36* | -.31* | -.20 | -.04 |
| | *p* | .012 | .032 | .162 | .778 |

*Note.* *$p < 0.05$

[1] For the sake of completeness, we did also run correlations between question-response accuracy rates and Negative Affect (NA) scores (range from 11 to 43; $M$ = 19.6, $SD$ = 6.1). No significant correlations were observed with NA. Factual-independent returned a correlation of -.05 ($p$ = .722), factual-dependent had a correlation of -.22 ($p$ = .132, hypothetical-independent had a correlation of .21 ($p$ = .149), and hypothetical-dependent had a correlation of -.12 ($p$ = .404).

Interestingly, moderate negative correlations were observed between PA scores and independent modals — regardless of context type. Nothing was found for dependent modal conditions. Given this result, we ran a correlational analysis for modal type and PA. The overall mean accuracy for independent modals was 93.21% (*SD* = 4.45%), vs. dependent modals where the value was 92.97% (*SD* = 5.12%). Figure 1 shows a relatively strong negative correlation between PA scores and question-response accuracy for independent modals ($r$ (47) = -0.43, $p$ = .002) (likely due to increased power due to increased number of items). Thus, participants with smaller PA scores had higher accuracy rates (conversely, participants with larger PA scores had lower accuracy rates) for independent modals, where no relationship was found for dependent modals. As expected, no correlation between dependent modals and PA scores was found ($r$ (47) = -0.13, $p$ = .371) (see Figure 2).

**Figure 1:** Correlation between question-response accuracy for independent modals and PA

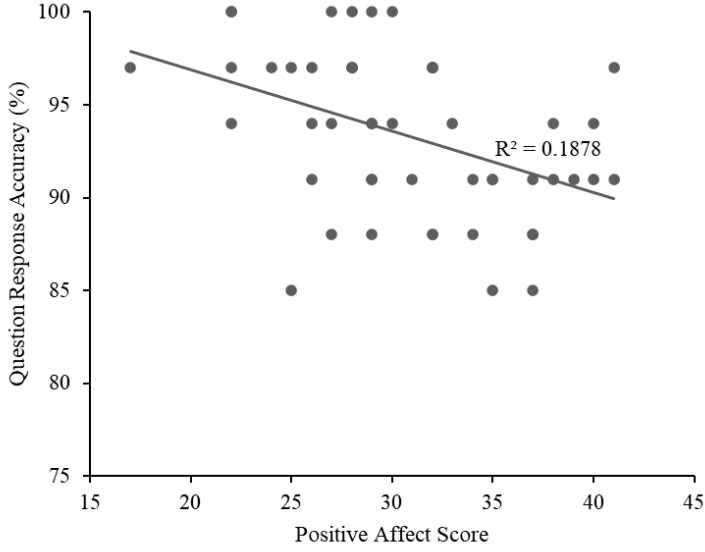
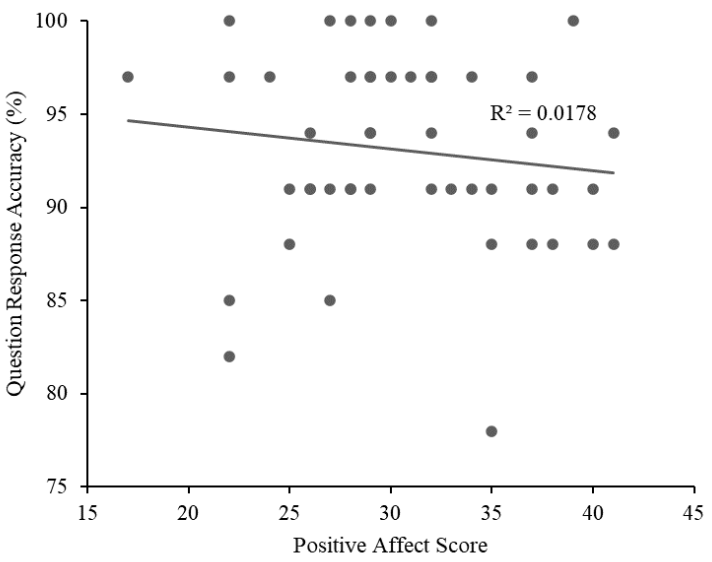


**Figure 2:** Correlation between question-response accuracy for dependent modals and PA




## 4 Discussion

We note that overall, the results showed that question-response accuracy rates were numerically higher in hypothetical vs. control contexts. As predicted, a robust (as indicated via effect size) difference for question-response accuracy rates was observed for dependent (*might, would*) vs. independent (*must, should*) modal sentences. The former modal type is preferably interpreted with non-factual restrictors whereas the latter need not have one for interpretive purposes. As such, when the discourse structure is incongruent with grammatical expectations, there is a cost — question-response accuracy rates were lower for dependent modal sentences embedded in control contexts. These results confirm the self-paced reading time findings of Dwivedi (1996), as well as the ERP findings of Dwivedi et al. (2006) and Dwivedi et al. (2010). This finding on its own is of interest for a few reasons. First, we note that the participants in the original study (Dwivedi 1996) were American English speakers in Massachusetts, circa 30 years ago, in contrast to more recent Canadian participants in Ontario. It is interesting to note that this grammatical contrast has not changed in time or via geographical considerations. Next, in an era of handwringing regarding the replication

crisis in psychology (see Schmidt & Oh 2016, among others), it is heartening to see an effect replicated across multiple methods and measures, over a span of several decades.

### 4.1 Low positive affect and structure

The present finding that low positive affect individuals respond differently to questions after independent vs. dependent modals supports our claims regarding findings in Selvanayagam et al. (2019). There, we proposed that individuals with low positive affect are not as engaged with sentence interpretation, and instead are focused on task accuracy. That is, rather than focusing on interpreting the sentences, they are focused on completing task requirements with as little effort as possible. Independent modals (*must, should*) do not require restrictive clauses for interpretive purposes (i.e., these are grammatically simpler, and/or have grammatically simpler discourse structures). As such, when sentences containing independent modals are presented (where these, by definition require less structure for interpretation), a facilitation effect emerges for low positive affect individuals — resulting in better question-response selection (Szucs & Soltész 2007). That is, the form and interpretation of the sentence stimuli allow for a more accurate response on behalf of low positive affect individuals since the stimuli are congruent with participant preferences for cognitive processing. This proposal would help explain the higher accuracy rates for independent modals for low positive affect individuals (i.e., negative correlation), where no relation is found for dependent modals. Because independent modals require less grammatical structure for interpretation, these are preferred by low positive affect participants. A carefully controlled follow-up study should be conducted to confirm this finding.

## 5 Concluding remarks

In sum, we investigated question-response accuracy rates to dependent (*might, would*) vs. independent (*must, should*) modal auxiliary sentences embedded in hypothetical vs. control contexts. We investigated two hypotheses: first, whether we would replicate previous findings regarding ease of processing when dependent modals were embedded in hypothetical contexts vs. control (factual) contexts. Second, we wanted to know whether positive affect would correlate with question-response accuracy rates. We did replicate our previous work showing a cost to interpretation when dependent modals were embedded in control

(factual) vs. hypothetical contexts. Our results also showed a negative correlation between question-response accuracy rates and positive affect for independent vs. dependent modals. We interpreted these findings as a facilitation effect — sentence stimuli that had fewer grammatical (and therefore structural) requirements for interpretation would be preferred for participants whose main focus was on task accuracy vs. sentence interpretation. These preliminary findings are among the first to relate dispositional affect to individual differences in sentence interpretation.

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