

An Experimental Investigation of Epistemic Modal Adverbs and Adjectives¹

Lavi Wolf – Ben-Gurion University of the Negev

Ariel Cohen – Ben-Gurion University of the Negev

Almog Simchon – Ben-Gurion University of the Negev

Abstract. This paper analyses epistemic modal adverbs and adjectives, both theoretically and experimentally, while addressing the prevalent conceptions of modality and context update. While modality is standardly viewed and represented uniformly, we show that epistemic modal adverbs and adjectives differ in various linguistic environments, and present experimental evidence that supports the claim that epistemic modal adverbs and adjectives differ in terms of cognitive processing. While context update is standardly viewed as a two-stage process composed of assertion and acceptance/rejection, we present experimental evidence that supports the claim that there is also a stage of evaluation, in which the hearer considers the content of the assertion and the implications of adding this content to the common ground.

Keywords: semantics, psycholinguistics, epistemic modality, modal adverbs, modal adjectives, context update

1. Introduction

This paper utilizes the differences between epistemic modal adverbs and adjectives as a means for an experimental investigation that sheds light on epistemic modals in general and their context update properties.

The prevalent conception of modality, following the work of Angelika Kratzer (inter alia 1981; 1991; 2012) is that all modals should be given a uniform account, as truth-conditional quantifiers over possible worlds. Possibility modals are existential quantifiers and necessity modals are universal. The domain of quantification is determined by conversational backgrounds, which are function from worlds to sets of propositions.

The prevalent conception of assertion and the context update process that follows this speech act, following the work of Robert Stalnaker (1978) is that there are two basic stages – the first in which the speaker performs the assertion and the second in which the hearer either accepts or rejects the assertion. Acceptance leads to context update of the asserted proposition, i.e. the proposition is added to the common ground and an intersection operation is applied to the context set, thereby reducing the set of worlds constituting it (for more details, see Stalnaker 1978).

¹ We would like to thank the audience at the poster session of *Sinn und Bedeutung 20*, and Christopher Piñón, Hedde Zeijlstra, Sascha Alexeyenko, Deniz Rudin and Hadas Kotek for the helpful comments.

However, these theories, as they stand, treat modal adjectives and adverbs in the same way, which, as we will see, is not the case. We present a theory that minimally revises the prevalent view so as to account for these differences, and test our theory experimentally.

The paper proceeds as follows: **section 2** presents data showing that epistemic modal adverbs and adjectives behave differently in various linguistic environments. **Section 3** presents the theoretical basis of this paper, based on Wolf (2015a) (an early version of which appears in Wolf and Cohen 2009), which accounts for these differences and lays the foundation for the experiment in **section 4**. **Section 5** concludes the paper.

2. The differences between epistemic modal adverbs and adjectives

Epistemic modal adverbs e.g. *possibly*, *probably* and *certainly* have the parallel epistemic modal adjectives *possible*, *probable*, and *certain*². This parallel is apparent when viewing minimal sentences containing epistemic modal adverbs and adjectives:

- (1) a. The dog is possibly on the lawn.
- b. It's possible that the dog is on the lawn.

The immediate impression is that both sentences are variants of each other, both conveying the same degree of possibility. And indeed, the early literature by and large does not distinguish between modal adverbs and modal adjectives (inter alia Jackendoff 1972; Jakobson 1978; Perkins 1983) However, it has become increasingly clear (cf. Bellert 1977; Nilsen 2004; Piñón 2006; Piñón 2009; Ernst 2009) that the story is not that simple.

We begin with the first and most recognizable feature of epistemic modal adverbs that distinguishes them from epistemic modal adjectives which is their *Speaker Orientedness* (cf. Jackendoff 1972). Utterances containing modal adverbs convey that the person whose judgment is reflected by these adverbs is the speaker. This feature does not standardly manifest in utterances containing modal adjectives, as can be seen in the following example (based on a similar example from Nuyts 2001:71):

- (2) A: It is probable that the stock market will crash.
B: Whose opinion is this?
- (3) A: The stock market will probably crash.
B: #Whose opinion is this?

² While non-epistemic interpretations of modal adjectives exist, this paper does not deal with them.

While the question in (2) is quite natural, i.e. the hearer wants to know whose judgment is conveyed by the speaker's assertion (while it may be the speaker's, it doesn't have to be), the question in (3) doesn't sound quite right. This is due to the intuition that in the modal adverb case it is clearly the speaker's judgment.

Another distinguishing element of epistemic modal adverbs and adjectives is behavior under various embeddings. Modal adjectives are easily embedded under negation while modal adverbs are difficult (Bellert 1977)³:

- (4) a. { It's impossible/not possible that
It's improbable/not probable that
It's uncertain/not certain that } ,John has/will come.
- b. { #Impossibly/Not possibly
#Improbably/Not probably
#Uncertainly/Not certainly } ,John has/will come.

Modal adjectives but not modal adverbs, are easily embedded under questions (Bellert 1977):

- (5) a. Is it possible/probable/certain that John has/will come?
b. #Has/Will John possibly/probably/certainly come?⁴

Modal adjectives but not modal adverbs are good in the antecedent of conditionals (Piñón 2006):

- (6) a. If it is possible/probable/certain that the socialists will win the elections, the rich will worry about a luxury tax.
b. #If the socialists possibly/probably/certainly win the elections, the rich will worry about a luxury tax.

Modal adjectives but not modal adverbs are easily embedded under factives (based on Papafragou (2006) concerning 'objective/subjective' epistemic modal auxiliaries):

³ Bellert also uses the pair *evident/evidently*. This is replaced by *certain/certainly* here, in order to keep the evidential component away.

⁴ Stressing the modal adverb in these examples results in higher acceptability due to focus. We do not deal with the effects of focus on modal adverbs here, but see Döring (2012).

(7) a. It is surprising that it is possible/probable/certain the socialists will win the elections.

b. #It is surprising that the socialists will possibly/probably/certainly win the elections.

Agreements and disagreement about utterances containing modal adjectives target the entire utterance, including the modal. Agreements and disagreement about utterances containing modal adjectives target the prejacent, precluding the modal (based on Papafragou's 2006 *assent-dissent* diagnostic, concerning 'objective/subjective' epistemic modal auxiliaries):

(8) A: It's possible/probable/certain that John is at home.

B: That's not true/I agree.

= It's not true/The hearer agrees that it's possible/probable/certain John is at home.

≠ It's not true/The hearer agrees that John is at home.

(9) A: John is possibly/probably/certainly at home.

B: That's not true/I agree.

≠ It's not true/The hearer agrees that John is possibly/probably/certainly at home.

= It's not true/The hearer agrees that John *is* at home.

Another conversational diagnostic is the *reason to assert* test (Wolf 2015a):

(10) Scenario: A reality show in which 15 participants are competing for the role of 'Israel' next top barista'. One of the participants got voted out, leaving 14.

Option A:

Spectator 1: It's possible that Danny will be Israel's next top barista.

Spectator 2: Why do you say that?

Spectator 1: Well, Dina was just voted out.

Option B:

Spectator 1: Danny will possibly be Israel's next top barista.

Spectator 2: Why do you say that?

Spectator 1: ??Well, Dinna was just voted out.

It seems that the fact that one participant was voted out is in itself not reason enough to assert the modal adverb possibility claim, which is puzzling if modal adverbs convey possibilities and nothing else. The last data item is the following contrast, from Nilsen (2004):

(11) It's possible that Le Pen will win even though he certainly won't.

(12) #Le Pen will possibly win even though he certainly won't.

This item, termed *Nilsen's contrast* in Piñón (2006) will receive a special treatment in the next section, as it is the basis of this paper's experiment. The initial motivation for this contrast is to show that there are differences between epistemic modal adverbs and adjectives, hence that they

should receive a different treatment. And there is an agreement among theories that discuss the differences between epistemic modal adverbs and adjectives (Piñón 2006, 2009; Ernst 2009; Nilsen 2004) that, in such contexts, the 'all adverb conjunction' (12) is infelicitous while the 'adjective-adverb conjunction' (11) is felicitous. We will take issue with this observation, and provide evidence which shows that while there are differences, they are subtler ones.

3. Theoretical basis

The theory that we adopt in this paper, which accounts for the abovementioned differences between epistemic modal adverbs and adjectives and underlies the experiment in the next section, is provided in Wolf (2015a, 2015b). Wolf explains the differences between epistemic modal adverbs and adjectives as differences between 'high' and 'very high' modals. Adopting the terminology and distinction between 'low' (root) modals which are located right above VP and 'high' (epistemic) modals which are located right above TP from Hacquard (inter alia 2006, 2010), Wolf proposes another location for epistemic modals which modify illocutionary force and are thus 'very high' – at ForceP (cf. Rizzi 1997). Epistemic modal adjectives correspond to 'high' modals and epistemic modal adverbs correspond to 'very high' modals. The former are truth-conditional and the latter use-conditional (on the expressive dimension and use-conditional, see Potts 2007; Gutzmann 2012; Gutzmann 2015). Truth-conditional epistemic modals convey possibilities and necessities in the same manner represented by the prevalent theory of modality, while use-conditional epistemic modals convey a degree of strength by which the speaker perform the assertion, i.e. the degree of confidence the speaker has regarding the prejacent.

Formally, the theory minimally modifies Stalnaker's (1978) system such that in addition to the common ground, the conversational context registers assertions which were previously performed and are currently under negotiation (see e.g. Ginzburg 2012; Farkas and Bruce 2010, for similar conversational registers). Each of these assertions is an expression of an information state (cf. Groenendijk Stokhof and Veltman 1995), represented in probabilistic terms (cf. Lassiter 2011b; Yalcin 2012), of some conversational participant with regards to a proposition. It is represented by the following assertion operator:

$$(13) A_x \langle S, C \rangle$$

In prose, the speaker x asserts propositional content C with a degree of strength S . The assertion operator itself is represented by the following shorthand probability function:

$$(14) A_x P(\varphi) = v$$

In prose, the speaker x asserts the probability function P which yields some probability value v when applied to propositional content φ . This value is defined on the speaker's information state i.e. the probability space of the speaker x and stands for the degree of belief of x in φ , which is the degree of strength for the sincerity condition of assertion. This degree of strength serves as *the* degree of strength of the assertion.

While an assertion is under *negotiation*, i.e. from the moment the assertion is performed and until it is accepted or rejected by conversational participants, it resides in the *Negotiation Zone* (NZ). The NZ is a set of assertion operators pertaining to various propositions. The manner by which conversational participants decide whether to accept or reject assertions is through an activation of a *mixture model*:

$$(15) \quad P(\varphi) = \sum_{i=1}^n w_i P_i(\varphi)$$

If the value of the mixture model surpasses some contextual threshold of acceptance, by assumption *high*, then the assertion is accepted and φ is updated into the common ground, i.e. the probability value assigned to φ becomes 1, and all information states in which the probability of φ is less than 1 are removed from the common ground. The difference between the standard Stalnakerian context update and the probabilistic context update proposed here, is as follows – figure 1 depicts a standard context update in which a proposition φ is added to the common ground thereby intersecting with the initial context set (CS). **Figure 1:**

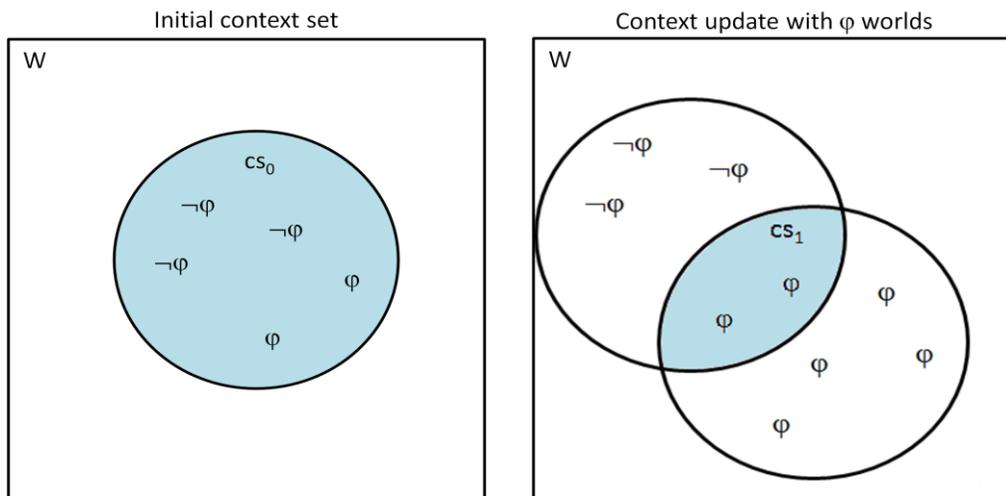


Figure 1: Standard context update.

The figure on the left depicts the initial context set as a set of worlds. Since nothing is known about φ , some of the worlds are φ worlds and others are *non- φ* worlds. The figure on the right depicts the new state of discourse once φ is accepted into the common ground – the proposition φ , a set of φ worlds, is intersected with the initial context set to yield the new one.

The initial context set in this paper is richer - it is composed of probability spaces, hence a more accurate representation of the initial probabilistic context set is as in **figure 2:**

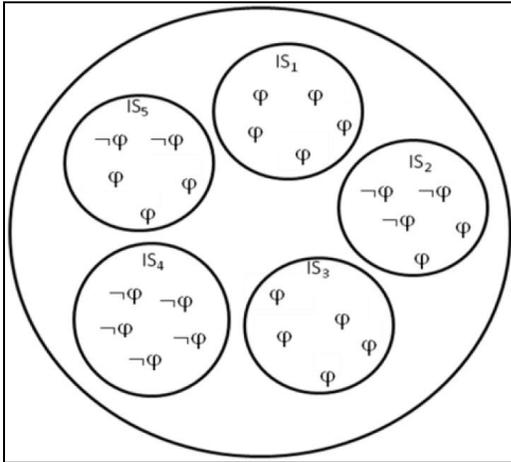


Figure 2: Probabilistic context set.

As can be seen, the probabilistic context set contains probability spaces rather than possible worlds, when each probability space is an information state *IS*.

We proceed with formal representations of non-modalized assertions, epistemic modal adjective assertions and epistemic modal adverb ones. When a speaker asserts a standard non-modified assertion the representation is:

- (16) The dog is on the lawn
 $A_x P(\text{on-the-lawn}(\text{the-dog})) \geq \text{high}$

In prose, the speaker asserts the propositional content ‘the dog is on the lawn’ with a degree of strength which is equal to or greater than *high*.

If this assertion is accepted and updated, this assertion’s Context Update Effect (CUE) will be to remove all information states except from figure 2’s *IS*₁ and *IS*₃ from the context set, since those are the information states in which the propositional content has a probability of 1.

When a speaker asserts an utterance containing an epistemic modal adjective such as *possible*:

- (17) It’s possible that the dog is on the lawn.
 $A_x P(P(\text{on-the-lawn}(\text{the-dog})) > 0) \geq \text{high}$

The speaker asserts the propositional content ‘it’s possible that the dog is on the lawn’, represented in probabilistic terms, i.e. ‘the probability that the dog is on the lawn is greater than 0’, with a degree of strength which is equal to or greater than *high*. Note that the degree of strength for a modal adjective-modified assertion is the same as the degree of strength for non-modified assertion, thus the chances of this assertion to be accepted by the hearer(s), everything else being equal, are the same as the chances of any non-modified assertion. Also note that the type of modal adjective does not affect the degree of strength but only the propositional content. If this assertion is accepted and updated, this assertion’s CUE will be removing *IS*₄ from the

context set, since this is the only information state in which the propositional content has a probability of 0.

The following are representations of the other modal adjectives-modified utterances:

(18) It's probable that the dog is on the lawn.

$A_x P(P(\text{on-the-lawn}(\text{the-dog})) > 0.5) \geq \text{high}$

(19) It's certain that the dog is on the lawn.

$A_x P(P(\text{on-the-lawn}(\text{the-dog})) = 1) \geq \text{high}$

We assume, following Yalcin (2010) and Lassiter (2011) that the degree assigned to *probable* is greater than 0.5. We also assume that the degree assigned to *certain* is the same as the degree assigned to necessity modals, i.e. 1 corresponding to full certainty. The CUE of (18) is to remove all information states except from IS_1 , IS_3 , and IS_5 from the context set, and the CUE of (19) is to remove all information states except from IS_1 , and IS_3 from the context set. Note that the CUE of (19) and (16) is the same, but the conversational impact is different. In (16) the speaker proposes to make the propositional content common ground, and in (19) the speaker claims that this propositional content is already common ground. Also note the entailment patterns – the stronger claims (19) and (16) illocutionary entail⁵ the weaker ones (18) and (17) since the CUE of the former is a subset of the CUE of the latter.

The representations of epistemic modal adverbs' modified assertions are:

(20) The dog is possibly on the lawn.

$A_x P(\text{on-the-lawn}(\text{the-dog})) > 0$

(21) The dog is probably on the lawn.

$A_x P(\text{on-the-lawn}(\text{the-dog})) > 0.5$

(22) The dog is certainly on the lawn.

$A_x P(\text{on-the-lawn}(\text{the-dog})) = 1$

The formulas state that the speaker asserts the propositional content 'the dog is on the lawn' with the degrees of strength equal to or greater than 0 (for *possibly*), to 0.5 (for *probably*) and equal to 1 (for *certainly*). Note the difference between modal adjectives and modal adverbs – the former modify the propositional content while the latter modify the degree of assertion. Note the similarity between epistemic modal adverbs and adjectives – both are represented by the same degrees of probability, since the lexical root of both is the same. The difference is a matter of scope – epistemic modal adverbs modify the whole speech act and therefore scope over the

⁵ An illocutionary act A_1 illocutionarily entails the act A_2 if it is impossible to perform A_1 without thereby performing A_2 (Searle and Vanderveken 1985).

propositional content, and epistemic modal adjectives modify the propositional content and therefore have narrow scope.

There are differences in terms of conversational effects as well. If accepted, the CUE of all of the modal adverbs-modified assertions is the same as the CUE of non-modalized assertions, i.e. removing all information states except from IS_1 , and IS_3 from the context set. However, asserting a modal adverb-modified utterance without the corresponding degree of belief is insincere. Thus, only the individuals holding information states IS_1 , and IS_3 can sincerely assert (22), only the individuals holding IS_1 , IS_3 and IS_5 can sincerely assert (21) and only the individuals holding IS_1 , IS_3 , IS_5 and IS_2 can sincerely assert (20).

Hence, the data in section 2 is explained: embeddability of modal adjectives is easier than modal adverbs because the former are part of the propositional content while the latter modify the speech act. Conversational agreements and disagreements target utterances including epistemic modal adjectives because they are conversational moves that determine whether or not the asserted content will be part of the common ground, and not whether the whole speech act together with its modification will, hence epistemic modal adverbs are left out. With regard to the *reason to assert* diagnostic, the scenario is reason enough to assert the epistemic modal adjective utterance because the speaker only asserts a possibility. The scenario is, however, not reason enough to assert the epistemic modal adverb, because in this case the speaker asserts (albeit with a *low* degree of force) the actuality of Danny's victory.

As for Nilsen's contrast – repeating the examples in (11) - (12):

(23) It's possible that Le Pen will win even though he certainly won't.

(24) #Le Pen will possibly win even though he certainly won't.

Following the formal representations presented above, these examples are represented respectively as:

(25) $A_x P(P(\text{win}(\text{Le-Pen})) > 0) \geq \text{high} \wedge A_x P(\neg \text{win}(\text{Le-Pen})) = 1$

(26) $A_x P(\text{win}(\text{Le-Pen})) > 0 \wedge A_x P(\neg \text{win}(\text{Le-Pen})) = 1$

The difference between the two assertions stems from the interplay between modification of the propositional content and modification of the speech act. In (25) the speaker asserts the propositional content 'it's possible that Le Pen will win' with the default degree of assertion *high*, and asserts the propositional content 'Le Pen will not win' with the degree of assertion 1 which corresponds to certainty. In (26) the speaker asserts the propositional content 'Le Pen will win' with the default degree of assertion *high*, and asserts the propositional content 'Le Pen will not win' with the degree of assertion 1 which corresponds to certainty.

Starting with the more straightforward 'all adverb' example (24), which is considered infelicitous in Nilsen. We agree that this is a simple example of an infelicitous, in fact contradictory, utterance. This is explained by the theory of this paper by (26) being *unassertable*. This is

because the speaker can't sincerely assert a proposition with a degree of belief of greater than 0 and its negation with a degree of belief of 1.

The 'adjective-adverb' sentence in (23) is judged felicitous by Nilsen, but the theory of this paper predicts it to be infelicitous. Specifically, (25) being *assertable but non-updatable*. The speaker can have a fully certain personal belief that a proposition is false, while acknowledging that at the time of utterance other conversational participants, i.e. other information states within the Probabilistic Common Ground (PCG) consider said proposition possible. However – the two conjuncts can't be updated into the PCG since the speaker is also a conversational participant, hence a member of the set of probability spaces composing it, and the speaker's beliefs in the 2nd conjunct contradict the common beliefs in the 1st. It is therefore important to ascertain whether sentence (23) is considered felicitous or not. We set out to test this issue experimentally.

4. Processing epistemic modal adverbs and adjectives

4.1. Predictions and rationale

Nilsen's contrast again:

(27) It's possible that Le Pen will win even though he certainly won't.

(28) #Le Pen will possibly win even though he certainly won't.

Following the theory presented in the previous section, we aim to check a couple of things. **First**, whether the adjective-adverb conjunct is actually felicitous, when the **prediction** stemming from the theory is that it isn't. This prediction goes together with the prevalent theory of modality and against the theory in Nilsen (2004). Does this mean that we claim no difference between epistemic modal adverbs and adjectives? No, for the following reasons. Firstly, recall that the empirical data in section 2 establishes the differences between epistemic modal adverbs and adjectives. Secondly, our claim is that while both sentences are infelicitous, they are infelicitous at *different context update stages*. Reiterating the point made in the previous section, we claim that the 'adverb-adverb' conjunct is *unassertable* i.e. (28) mean that the speaker asserts the contradictory propositions 'Le Pen will win' and 'Le Pen will not win', the first with a low degree of certainty and the second with a full degree of certainty. The propositions contradict, and the degrees of certainty are incompatible. Note that if the degree of strength of the second conjunct were *less* than full, we predict that there wouldn't be any contradiction, which is indeed the case:

(29) Le Pen will possibly win even though he *probably* won't.

(27), on the other hand is *assertable but not updatable*, i.e. it passes the assertion stage which takes into consideration both the propositional content and the source of evidence (i.e. the conversational participants whose degree of certainty is at issue) but cannot pass the context update stage, which is only concerned with propositional contents, and those are contradictory.

The **second prediction**, following this rationale, is therefore that since the sentences fail at different context update stages, there would be a difference in reaction times. The infelicity of the adverb-adverb conjunct arises at the first stage of context update, i.e. it cannot pass from the assertion performance stage into the evaluation stage. Hence, we predict a relatively short reaction time. The infelicity of the adjective-adverb conjunct arises at a later stage, i.e. it cannot pass from the evaluation stage into the context update stage. Hence, we predict a longer reaction time. This prediction goes *against* the prevalent theory of modality and *with* the (spirit of) Nilsen (2004).

4.2. Experimental design

We manipulated the type of the modal in the first conjunct. This modal was either an epistemic modal adjective, i.e. a truth-conditional 'high' modal or an epistemic modal adverb, i.e. a use-conditional 'very high' modal. The sentences were Nilsen-type ones, to which we made the following modifications: using the contrastive conjunct *but* instead of Nilsen's 'even though' in order to reduce the extra complexity inherent to *even*. Replacing the negation at the end of the second conjunct with an antonym in order to reduce the complexity of another operator. Providing a context via a profession. Balancing the gender, alternating between male and female common names. Resulting in sentences of the following type⁶:

Adjective-adverb conjuncts:

(30) It's possible that Jane the actress will accept the job but she will certainly refuse it.

Adverb-adverb conjuncts:

(31) John the gambler will possibly win the game but he will certainly lose it.

There were 16 experimental items, composed of 8 adjective-adverb conjuncts and 8 adverb-adverb conjuncts. In order to control the sentential contexts, the items were used in two versions, turning the adjective-adverb conjuncts of version A into adverb-adverb conjuncts in version B, in the following manner:

(32) Jane the actress will possibly accept the job but she will certainly refuse it.

(33) It's possible that John the gambler will win the game but he will certainly lose it.

⁶ The preamble in which participants are provided with instructions and a practice session states that both conjuncts occur simultaneously, so as to avoid an interpretation of (30) where Jane refuses the job at some time but accepts it at another time.

There were also 16 control items, composed of uncontroversially felicitous and infelicitous sentences. Among the felicitous, we used possibility adjective-adverb or adverb-adverb conjuncts such as:

(34) It's possible that Patricia the rocker will admit the addiction but she will possibly deny it.

(35) James the banker will possibly authorize the payment but he will possibly withhold it.

Felicitous sentences with no modals:

(36) Jennifer the painter will finish the painting but she will hide it.

Infelicitous necessity adjective-adverb or adverb-adverb conjuncts:

(37) It's certain that David the lawyer will accept the settlement but he will certainly deny it.

(38) Elizabeth the athlete will certainly complete the marathon but she will certainly quit it.

Infelicitous sentences with no modals:

(39) Christopher the mayor will accept the petition but he will reject it.

4.3. Methods

We used two different experimental tasks: **acceptability judgments** based on a 7 point Likert scale, and binary acceptability judgments in which we also checked for **reaction times (RT)**. In the Likert task, subjects were instructed to rate the degree of sentence quality of the sentences from 1 to 7, 1 being the best – completely coherent, and 7 being the worst – completely incoherent. The sentences were presented in a randomized order with an attention test presented half-way through the experiment.

The **RT** task used a jspsych (<http://www.jspsych.org/>) toolbox for javascript. We ran a Rapid Serial Visual Presentation (RSVP) paradigm. Each word was presented for 300ms with 150ms interval between each word. Participants were instructed to decide whether a given sentence was “good and coherent” or “bad and incoherent” by clicking ‘z’ or ‘m’ respectively. Analysis was performed only from the appearance of a decision screen following the last word of the sentence. Again, sentences were randomized between subjects with an attention test prompting half-way through.

Participants were recruited over Amazon Mechanical Turk (cf. Sprouse 2011 on Amazon Mechanical Turk's reliability as an experimental tool). 50 subject participated in the Likert experiment and 90 participated in the reaction time experiment, all native speakers of English.

4.4. Results

Beginning with the acceptability judgments in the Likert task experiment, the following figure shows the means of participants' judgments. **Figure 3:**

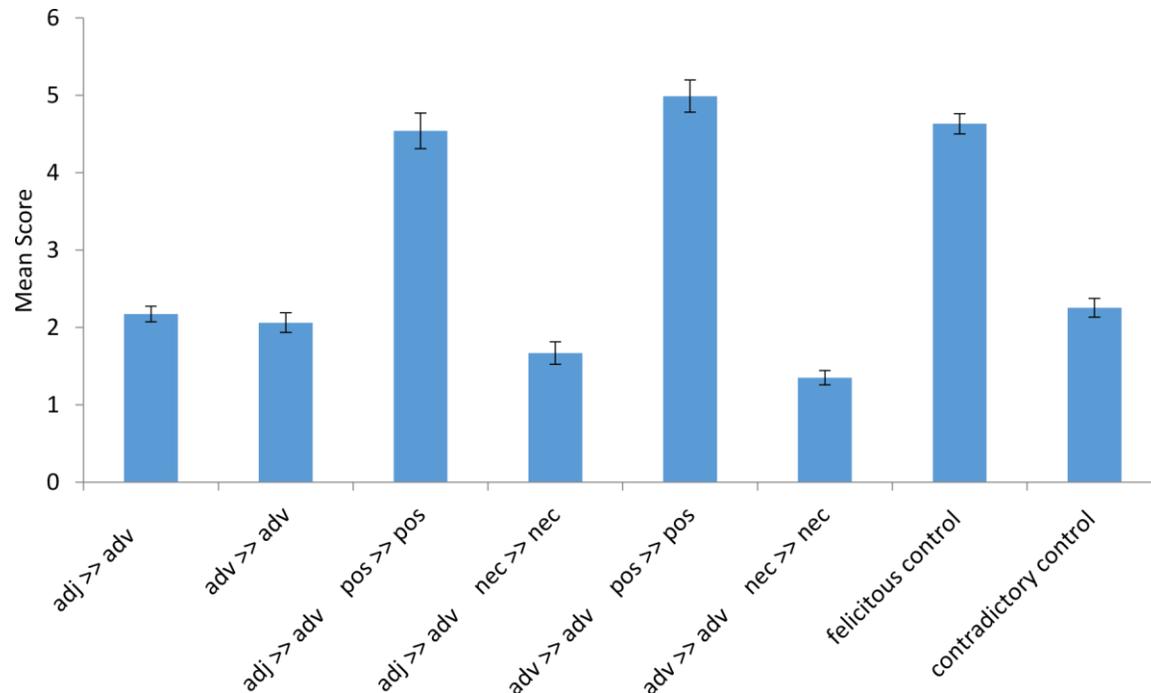


Figure 3: Mean score in each condition. Error bars denote standard errors.

A paired sample t-test performed on the adjective-adverb and adverb-adverb conjuncts showed that they were rejected in pretty much the same way, with no significant difference [$t(49) = 1.35$, $p = .18$]. On the other hand, repeated Measures ANOVA with the adjective-adverb and adverb-adverb conjuncts, felicitous and contradictory control items reveals significant difference [$F(3,147) = 149.76$, $p < .001$]. Post hoc comparisons show that this effect stems significantly from the mean score of the felicitous control items to be higher than the rest [$F(1,49) = 219.44$, $p < .001$] i.e. the adjective-adverb and adverb-adverb conjuncts are judged together with the contradictory control. Furthermore, no significant difference was observed from contrasting the adjective-adverb and adverb-adverb conjuncts with the contradictory control [$F(1,49) = 1.92$, $p = .17$].

Proceeding with the RT (RSVP) experiment, the following figure depicts the acceptability judgments in this task. **Figure 4:**

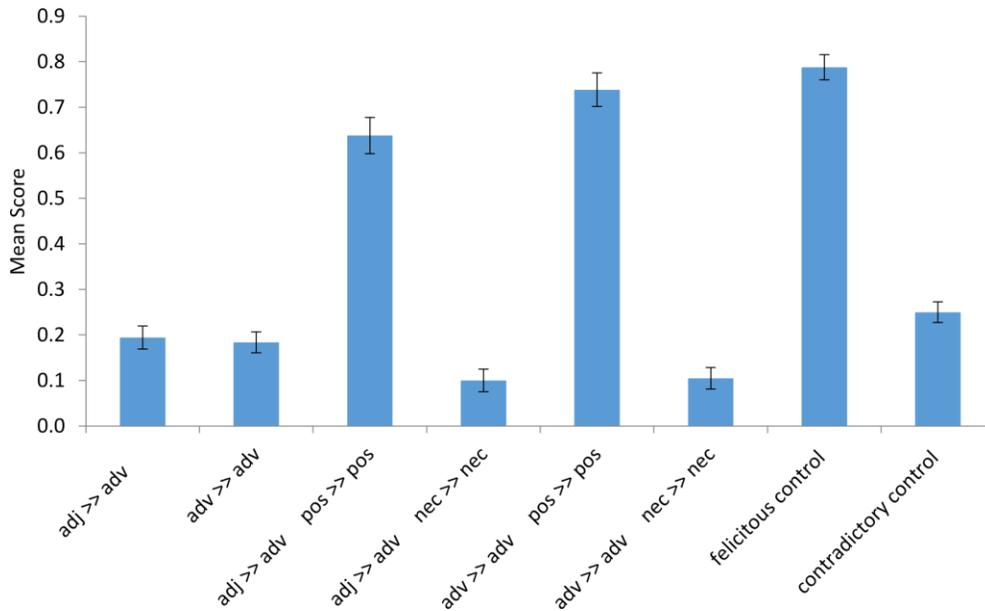


Figure 4: Mean score in the RSVP task. Error bars denote standard errors. Some observations were not taken into account since the participant clicked a different key other than ‘m’ or ‘z’.

We first analyzed the scores given to the different constructions, and the results are similar to the previous experiment. Again, a paired sample t-test of adjective-adverb and adverb-adverb conjuncts shows that they are judged the same, with no significant difference [$t(84) = 0.08, p = .93$]. Interestingly, Repeated Measures ANOVA with the adjective-adverb and adverb-adverb conjuncts, felicitous and contradictory control items reveals significant difference [$F(3,80) = 176.69, p < .001$] while post hoc comparisons shows this effect stems significantly from the mean score of the felicitous control items being higher than the rest [$F(1,80) = 286.79, p < .001$]. A significant difference was also observed from contrasting the adjective-adverb and adverb-adverb conjuncts with the contradictory control [$F(1,80) = 5.94, p = .017$]. The picture is different when we consider reaction times. **Figure 5:**

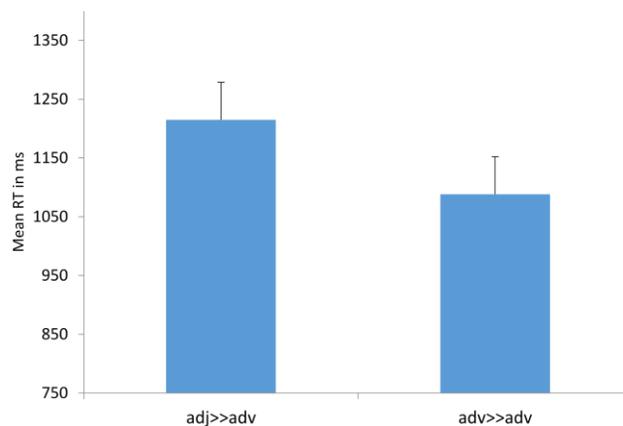


Figure 5: Mean RT. Error bars denote standard error of the mean difference.

We performed a paired-sample t-test on mean RT between the conjuncts. N=90, three subjects were excluded due to failure in attention test. In accordance with our assumption, we found a significant effect in which participants preformed slower on the adjective-adverb trials compared to the adverb-adverb ones [$t(86) = 1.98$, $p = .05$].

4.5. Discussion

The first hypothesis, i.e. that both the adjective-adverb and adverb-adverb conjuncts would be infelicitous is corroborated. As can be seen in the Likert results, the adjective-adverb and adverb-adverb conjuncts pattern together with the infelicitous control items. There is no significant difference between the conjuncts themselves, and there is no significant difference between the conjuncts and the contradictory control. There is however a significant difference between the conjuncts + contradictory control and the felicitous control, when the latter has higher values than the former.

Moreover, the results of the Likert acceptability judgment task nicely match the results of the RT judgment task, i.e. the adjective-adverb and adverb-adverb conjuncts as well as the infelicitous control items receive low acceptability scores while the felicitous control items receive high acceptability scores. In this task both of the conjuncts received significantly *lower* scores than the contradictory control, marking them, of course, as contradictory as well.

As for the second hypothesis, i.e. that in terms of reaction times adjective-adverb conjuncts will take longer to process than the adverb-adverb conjunct, this is also corroborated with a significant effect. While this establishes that there are differences, the effect is not as significant as we would like it to be. We speculate that this is due to the multiplicity of control items, and hypothesize that in a minimal experiment contrasting adjective-adverb and adverb-adverb conjuncts directly the effect would be bigger, but this is a matter for future research.

The two experiments complement each other in a way that dovetails between the prevalent theory of modality and Nilsen's theory. Experiment 1 established that Nilsen's contrast is not really a contrast, thereby supporting the prevalent theory of modality. Experiment 2 establishes that there are differences between epistemic modal adverbs and adjectives in terms of processing time, thereby pointing the need for a revision of the prevalent theory of modality. This revision may be minimal, if we only consider epistemic modal adverbs and adjectives⁷. But there are data that show similar differences to the ones seen here, in the epistemic modal auxiliary domain (cf. Lyons 1977; Papafragou 2006; Portner 2009; Wolf 2015a), which point to the need to reconsider the epistemic modality realm in general.

⁷ For example, Hacquard (2013) distinguishes between *grammatical modality* inherent to modal auxiliaries and *lexical modality* inherent to e.g. adverbs and adjectives.

5. Conclusion

This paper presents empirical and new experimental data on epistemic modal adverbs and adjectives. These data support the view that there is a distinction between these two types of epistemic modals, and suggest that this distinction manifests both in the truth-conditional level and the use-conditional one, with implications on the context update process.

We propose expansions to the prevalent Kratzerian theory of modality and the prevalent Stalnakerian theory of context update and put these proposals to the test by two experiments. Both experiments have an acceptability judgment component, and the second experiment adds a reaction time component. In terms of acceptability judgments, the experimental results support the proposal of the abovementioned differences, specifically the proposal to distinguish between truth-conditional and use-conditional epistemic modality. In terms of reaction times, the experimental results support the proposal to add another level to the context update process, namely the level of evaluation before updating propositions into the common ground.

We hope that the paradigm presented here will inspire the investigation of further theoretical questions concerning epistemic modal adverbs and adjectives and the nature of epistemic modality and the assertion process.

References

- Bellert, I. (1977). On semantic and distributional properties of sentential adverbs. *Linguistic Inquiry*, 8(2), 337–351.
- Döring, S. (2012). The focus sensitivity of sentence adverbs. In *Proceedings of ConSOLE XIX* (pp. 201–214).
- Ernst, T. (2009). Speaker-oriented adverbs. *Natural Language & Linguistic Theory*, 27(3), 497–544.
- Farkas, D. F., & Bruce, K. B. (2010). On reacting to assertions and polar questions. *Journal of Semantics*, 27(1), 81–118.
- Ginzburg, J. (2012). *The interactive stance*. Oxford University Press.
- Groenendijk, J., Stokhof, M., & Veltman, F. (1995). Coreference and contextually restricted quantification. In *Proceedings of SALT vol.5* (pp. 112–129).
- Gutzmann, D. (2012). *Use-conditional meaning*. *Studies in multidimensional semantics*. Doctoral dissertation. University of Frankfurt.
- Gutzmann, D. (2015). *Use-conditional meaning: Studies in multidimensional semantics*. Oxford: Oxford University Press.
- Hacquard, V. (2006). *Aspects of modality*. Massachusetts Institute of Technology. PhD dissertation.
- Hacquard, V. (2010). On the event relativity of modal auxiliaries. *Natural Language Semantics*, 18(1), 79–114.
- Hacquard, V. (2013). The grammatical category of modality. In *Proceedings of the 19th Amsterdam Colloquium* (pp. 19–26).

- Jackendoff, R. (1972). *Semantic Interpretation in Generative Grammar*. *Studies in linguistics series 2* (Vol. R.). Cambridge, MA: The MIT Press.
- Jacobson, S. (1978). On the use, meaning, and syntax of English preverbal adverbs. *Acta Universitatis Stockholmiensis. Stockholm Studies in English*, (44), 5–160.
- Kratzer, A. (1981). The notional category of modality. In H.-J. Eikmeyer & H. Rieser (Eds.), *Words, Worlds, and Contexts: New Approaches in Word Semantics* (pp. 38–74). Berlin: Walter de Gruyter.
- Kratzer, A. (1991). Modality. In A. von Stechow & D. Wunderlich (Eds.), *Semantik/Semantics: An International Handbook of Contemporary Research* (pp. 639–50). Berlin: de Gruyter.
- Kratzer, A. (2012). *Modals and conditionals: New and revised perspectives*. Oxford: Oxford University Press.
- Lassiter, D. (2011a). Gradable epistemic modals, probability, and scale structure. In N. Li & D. Lutz (Eds.), *Semantics and Linguistic Theory (SALT)* (Vol. ZZ, pp. 197–215).
- Lassiter, D. (2011b). *Measurement and Modality: The Scalar Basis of Modal Semantics*. New York University Dissertation.
- Lyons, J. (1977). *Semantics*. Cambridge: Cambridge University Press.
- Nilsen, Ø. (2004). Domains for adverbs. *Lingua*, 114(6), 809–847.
- Nuyts, J. (2001). *Epistemic Modality, Language, and Conceptualization: A cognitive-pragmatic perspective*. *Human Cognitive Processing*. John Benjamins.
- Papafragou, A. (2006). Epistemic modality and truth conditions. *Lingua*, 116(10), 1688–1702.
- Perkins, M. R. (1983). *Modal expressions in English*. London: Pinter.
- Piñón, C. (2006). Modal adverbs again. In *Honoring Anita Mittwoch on her 80th birthday, Syntax, Lexicon, and Event Structure, The Hebrew University of Jerusalem* (pp. 1–6).
- Piñón, C. (2009). The thing about modal adverbs. *Snippets*, (20).
- Portner, P. (2009). *Modality*. Oxford: Oxford University Press.
- Potts, C. (2007). The expressive dimension. *Theoretical Linguistics*, 33, 165–198.
- Rizzi, L. (1997). The fine structure of the left periphery. In L. Haegeman (Ed.), *Elements of Grammar* (pp. 281–337). Dordrecht: Kluwer.
- Searle, J. R., & Vanderveken, D. (1985). *Foundations of Illocutionary Logic*. Cambridge: Cambridge University Press.
- Sprouse, J. (2011). A validation of Amazon Mechanical Turk for the collection of acceptability judgments in linguistic theory. *Behavior Research Methods*, 43(1), 155–167.
- Stalnaker, R. (1978). Assertion. *Cole, Peter, Ed.: Pragmatics. Syntax and Semantics*. New York: Academic Press, ., 9, 315–332.
- Wolf, L. (2015a). *Degrees of Assertion*. *PhD dissertation*. Ben-Gurion University of the Negev.
- Wolf, L. (2015b). It's probably certain. In *Proceedings of the Israel Association of Theoretical Linguistics 30*. Ben-Gurion University of the Negev.
- Wolf, L., & Cohen, A. (2009). Modal Adverbs as Negotiation Chips. *International Journal for Language Data Processing, Sprache Und Datenverarbeitung*., 33(1-2), 169–177.
- Yalcin, S. (2010). Probability Operators. *Philosophy Compass*, 5, 916–937.
- Yalcin, S. (2012). Bayesian Expressivism. In *Proceedings of the Aristotelian Society (Hardback)* (Vol. 112, pp. 123–160). Blackwell Publishing Ltd.