Belief update in Kratzerian Modality theory

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RULing XII

Nandao-Qs and the impact of contextual evidence

In Mandarin, questions containing the adverb *nandao* (*Nandao-Qs*) **necessarily** express a **negative epistemic** bias (Xu 2013, 2017). The bias can be strong (i.e. rhetorical reading) (Yu 1984, Qi & Ding 2006, Yu 2006, Xu 2012) or weak (i.e. information-seeking reading) (Gong 1995, Su 2000, Sun 2007, Xu 2013) depending on contexts.

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Example (*Nandao-p?* in neutral context: rhetorical question)

(1) (A's house is messy. One day, A's friend B visits him and suggests he clean it.)

A: Nandao ni shi wo ma ma?
nandao you be I mom Y/N-Q

'What are you, my mom or something?'
= 'You are not my mom!'

Example (*Nandao-p?* with evidence against *p*: rhetorical question)

(2) (A and B are talking about the war in Afghanistan. A thinks the US should retreat, while B disagrees. They know each other's stance quite well.)

A: The US government cannot spend more money to keep the troops in Afghanistan.

B: But Al-Qaeda is still in power. We need the US troops to eliminate them once and for all.

A: More than two thousand soldiers have died!

Nandao meijun yinggai jixu zai Afuhan
Nandao US.troop should continue at Afghanistan
zhujun?
station.troop

'The US troops shouldn't continue to stay in Afghanistan, right?'

Example (*Nandao-p?* with evidence for *p*: info-seeking biased Q)

(3) (Policeman A strongly believes criminal B has not escaped. During a search, A finds a receipt of yesterday's flight in B's name. So, A asks his colleagues,)

A: Nandao ta feizou-le ma?
nandao he fly.go-ASP Y/N-Q

'He hasn't escaped, right?' $\neq$ 'He hasn't escaped.'

A summary of *nandao-p?* uses

Nandao-p?	Speaker's bias towards p	Neutral	Speaker's bias against p
Evidence for p	$\times$	$\times$	✓(IQ)
Neutral	$\times$	$\times$	✓(RQ)
Evidence against p	$\times$	$\times$	✓(RQ)

The meaning of bias in Kratzerian Modality Theory

The core meaning of *nandao* in *nandao-p?* is the epistemic bias, i.e. the speaker believes that the correct answer is more likely to be$\neg p$ than p. Such an epistemic modal meaning can be represented in Kratzerian framework for modality using the notation of **Comparative Possibility** Kratzer (1981).

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Definition (Comparative Possibility)

(4) ϕ is more possible than ψ (written as $\phi \succ^{s}_{g(w)} \psi$) iff $\phi \succeq^{s}_{g(w)} \psi$ and $\psi \not\succeq^{s}_{g(w)} \phi$, given $\succeq^{s}_{g(w)} := \{(\phi, \psi) | \ \forall u \in \psi \exists v : v \preceq_{g(w)} u \wedge v \in \phi\}$, where $u, v \in \bigcap f(w)$. (adapted from Lassiter 2011: 21-22)

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Thus, in a *nandao-p*?, the core meaning of bias can be represented as the speaker believes that $\neg p \succ^{s}_{g(w)} p$ (Xu 2017).

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- Con($\neg p$) is defined as a set of contextual evidence against p

Simple explanations of the impacts of contextual evidence

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Epistemic bias + Contextual evidence → RQ/IQ

- Both RQ and IQ uses are within the spectrum of the semantics of nandao-Q
- RQ/IQ readings depend on how the context affects the speaker's epistemic states
- RQ and IQ uses are different in modal force

Research questions

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- What does it mean by "(contextual) evidence for/against p"?
- How does the (contextual) evidence affect the two conversational backgrounds, namely modal base and ordering source?

Types of contextual evidence

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On the other hand, direct evidence is fully reliable and is able to guarantee the true of p. This type of evidence can be obtained by direct witness (e.g. first personal perception) or by entailment. Thus, the propositional contents of direct evidence include only p-worlds or $\neg p$-worlds.

Example of *nandao*-Q with direct contextual evidence

Example (RQ use of *nandao-p?* with direct evidence against *p*)

(A and B are in a sound-proof office. There is only one window, and there is a curtain over the window. A and B cannot see or hear anything outside. They are arguing about what the weather is like outside. A insists it is sunny outside, while B believes that it is raining. In order to convince B, A draws aside the curtain. Sunshine comes inside through the window.)

A: Ni kan! Nandao waimian zai xiayu ma?
You look nandao outside PROG rain Y/N-Q
'Look! It is not raining outside!'

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Question

In the double relativity system, how can we model that Con($\neg p$) decreases the possibility of p (at the same time, increases the possibility of $\neg p$)?

General remarks about contextual evidence

In case of *nandao*-Qs, the ordering source includes what the speaker knows or believes when he thinks of the possible answers. When he judges the answers, he bases his judgment on facts, personal experience, as well as heuristics, all of which constitutes his epistemic states and the epistemic ordering source $g(w)$. When Con($\neg p$) is added, the speaker will reconsider the answers based on the new information. If Con($\neg p$) is (contextual) evidence, it updates the facts for judgment; If it is (contextual) reasoning, it updates the epistemic generalizations. Either way, Con($\neg p$) will **update** $g(w)$.

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$g(w) \overset{\text{Evi 1}}{\Longrightarrow} g'(w) \overset{\text{Evi 2}}{\Longrightarrow} g''(w) \ldots$

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When the contextual evidence is available in the context, there are many ways it may affect the context, e.g. restricting the modal base or updating the ordering source. We will focus on updating the ordering source for now and come back to the possibility of modal base restriction.

Ordering source update

In the literature, scholars propose various ways to deal with modality problems concerning ordering source by means of ordering semantics innovations, e.g. ordered sequence of multiple ordering sources (von Fintel & Iatridou 2008), ordering source add-up (Katz et al 2012), ordered merging of ordering sources (ibid.), and ranked ordering sources (Reisinger 2016). But we are coping with none of the problems mentioned in the literature using those innovations. Our problem is not concerning weak/strong necessity, number of expectations, or prioritized sets of priorities. Ours is about how a piece of contextual evidence changes the ordering source.

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For the reason of simplicity and reasons that will be addressed later, we will try the simple update of ordering source.

Example (Simple update of ordering source)

$g'(w) = g(w) \cup R$, where R is a set of propositions.

Dynamics of contextual evidence propositions

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The above tells us that when adding a set of propositions to an ordering source via simple update, it is equivalent to just update the ordering source with each proposition in the set subsequently. This property of simple update can make our task easier, because we don't have to focus on updating an ordering source with a set of propositions, instead we can just look at the simplest case, i.e. updating the ordering source with just one proposition and repeat this kind of process subsequently.

A mini context

Example

Context:

1. $\bigcap f(w) = \{w_1, w_2, w_3, w_4, w_5, w_6\}$,
2. $p = \{w_3, w_4, w_5\}$ (shown in red in figures)
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Then:

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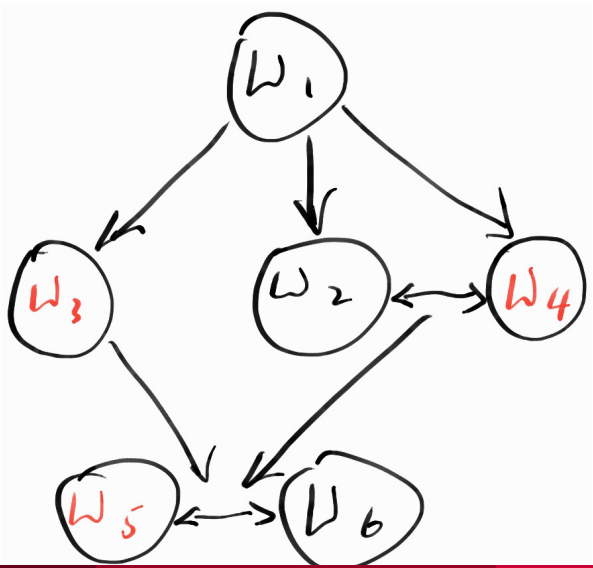

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Let's try a singleton Con($\neg p$) with more $\neg p$-worlds with the above context.

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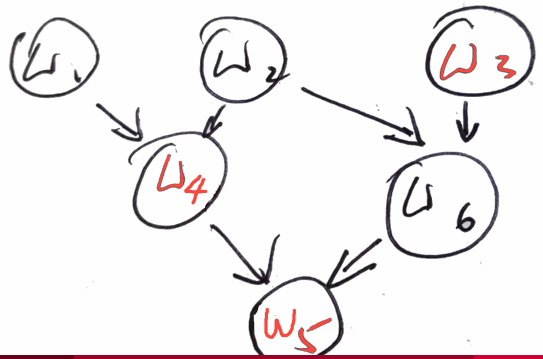

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Even though there are more $\neg p$-worlds in $\text{Con}(\neg p)$ which is supposed to make $\neg p$ rank even higher than p given $g'(w)$. But, it turns out to show that $\neg p \not\succ^s_{g'w} p$, because the addition of w_3 in $\text{Con}(\neg p)$ makes w_3 one of $\textsc{Best}(f(w), g(w))$. From the definition of $\succ^s_{g'w}$, we know that $\neg p \succ^s_{g'(w)} p$ would be impossible.

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Conclusion

The above discussion showed us that not every more-$\neg p$-proposition can be included in Con($\neg p$). At least, those that make at least one of p-worlds one of $\textsc{Best}(f(w), g(w))$ cannot.

Step back

Question

How can we model that there is an increase or degrease in possibility of $p/\neg p$ considering $\mathrm{Con}(p/\neg p)$?

Hint from Kratzer (1981)

Example (*The Murder*'s case)

The Murder:
Much-Girgl has been murdered on his way home. The police start investigations. Certain conclusions may be drawn from what is known about the circumstances of the crime. Utterances of the following sentences are likely to have occurred in such a situation:
(4) . . . *Kastenjakl may be the murder.*
(5) . . . *Gauzner-Michl must be the murderer.*
. . .

Hint from Kratzer (1981)

Example (*The Murder*'s case (cont.))

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The police inspector does not know that the real world is like. But he can draw conclusions from the growing evidence available to him.

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The police inspector does not know that the real world is like. But he can draw conclusions from the growing evidence available to him.

As we can see from the murder example, the degrees of the possibility of the proposition *Gauzner-Michl is the murderer* will change according to incremental evidence available to the inspector.

Kratzer's graded modalities

Definition (Human possibility)

A proposition p is a human necessity in a world w with respect to a modal base f and an ordering source g if, and only if, the following condition is fulfilled:

1. $v \preceq_{g(w)} u$, and
2. for all $z \in \bigcap f(w)$: if $z \preceq_{g(w)} v$, then $z \in p$. (Kratzer 1981: 47-48)

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Definition (Weak necessity)

A proposition p is a weak necessity in w with respect to a modal base f and an ordering source g iff p is a better possibility than $\neg p$ in w with respect to f and g. (Kratzer 1991a)

Kratzer's graded modalities

Definition (Human possibility)

A proposition p is a possibility in w with respect to a modal base f and an ordering source g iff $\neg p$ is not a necessity in w with respect to f and g.

(adapted from Kratzer 1981: 48)

Kratzer's graded modalities

Definition (Human possibility)

A proposition p is a possibility in w with respect to a modal base f and an ordering source g iff $\neg p$ is not a necessity in w with respect to f and g.

(adapted from Kratzer 1981: 48)

Definition (Slight possibility)

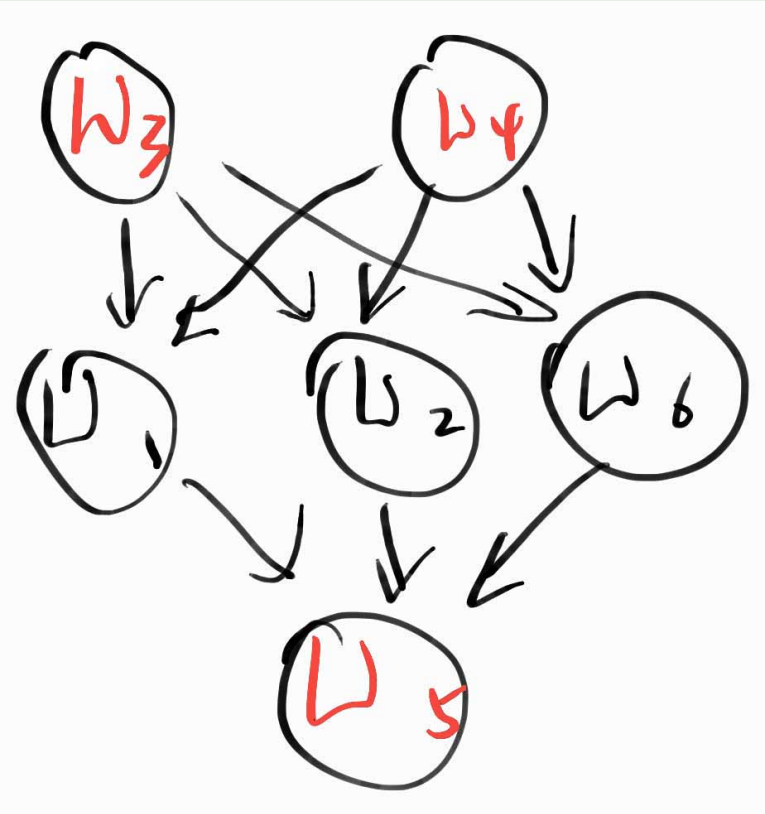
A proposition p is a slight possibility in w with respect to a modal base f and an ordering source g iff

1. p is compatible with $f(w)$; and
2. $\neg p$ is a necessity in w with respect to f and g. (Portner 2009: 69)

Examples under Limit Assumption

Example (Human necessity)

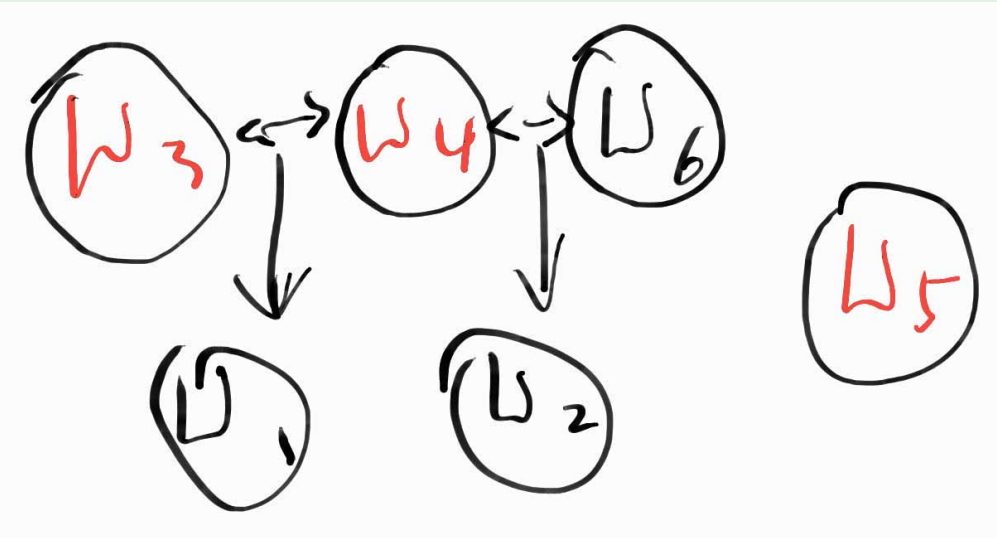
$\forall w'(w' \in Best(f(w), g(w)) \Longrightarrow w' \in p)$.



Examples under Limit Assumption

Example (Weak necessity but no human necessity)

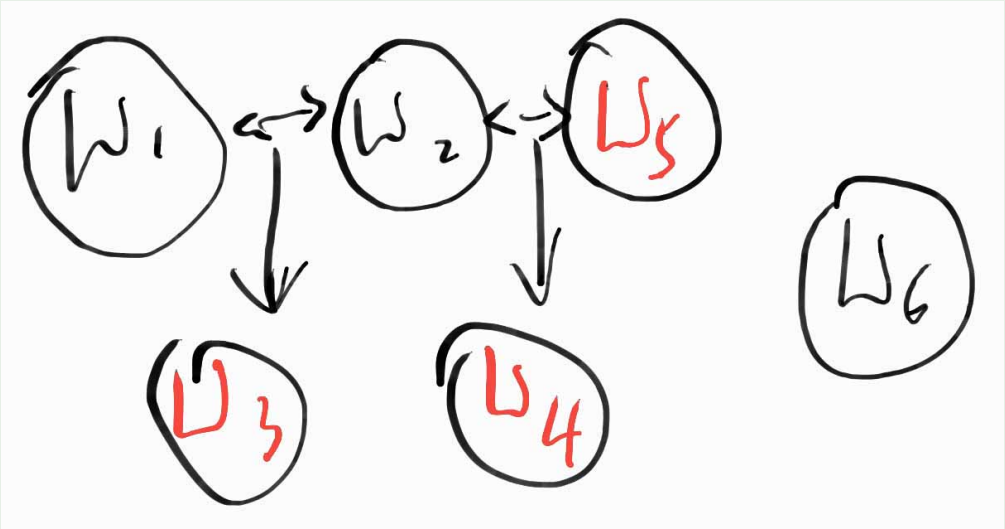
$p \succ^{s}_{g(w)} \neg p$ and $\neg \forall w''(w'' \in Best(f(w), g(w)) \Longrightarrow w'' \in p)$



Examples under Limit Assumption

Example (Human possibility (on a lesser end))

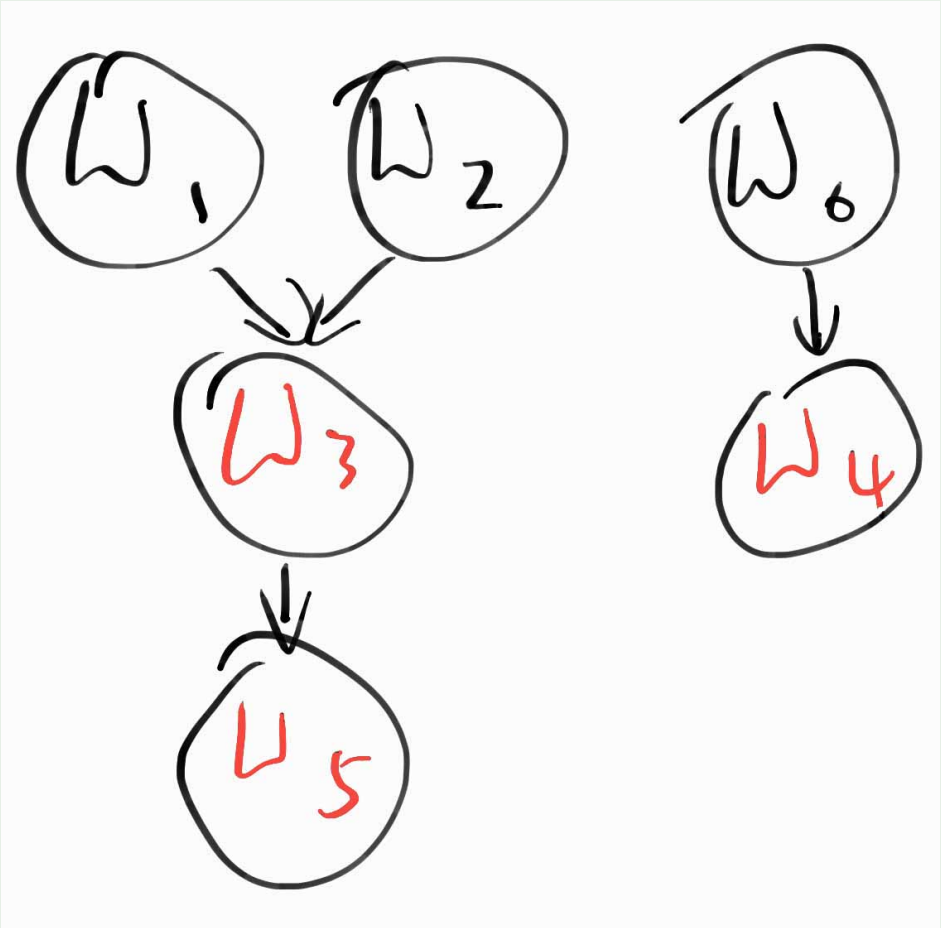
$\neg p \succ^{s}_{g(w)} p$ and $\neg \forall w'(w' \in Best(f(w), g(w)) \Longrightarrow w' \in \neg p)$



Examples under Limit Assumption

Example (Slight possibility)

$p \cap \bigcap f(w) \neq \emptyset$ and $\forall w'(w' \in Best(f(w), g(w)) \Longrightarrow w' \in \neg p)$



A tentative conclusion

As we can see from the above summary, when the degree of the possibility of p decreases, the number of p-worlds in $\textsc{Best}(f(w), g(w))$ also decreases. By the law of excluded middle, the domain universe $\bigcap f(w)$ is exhausted by the bipartition of p and $\neg p$. So, the decrease of p-worlds in $\textsc{Best}(f(w), g(w))$ means the increase of $\neg p$-worlds in $\textsc{Best}(f(w), g(w))$.

A counterexample

Example

Context:

1. $\bigcap f(w) = \{w_1, w_2, w_3, w_4, w_5, w_6\}$,
2. $p = \{w_3, w_4, w_5\}$
3. $\neg p = \{w_1, w_2, w_6\}$
4. $g(w) = \{\{w_1, w_3, w_4, w_5\}, \{w_1, w_2, w_3, w_4\}\}$
5. $\textsc{Best}(f(w), g(w)) = \{w_1, w_3, w_4\}$

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5. $\textsc{Best}(f(w), g(w)) = \{w_1, w_3, w_4\}$

Then, given f and g relevant to the world w,

6. $p \approx^s_{g(w)} \neg p$ (i.e. $p \succeq^s_{g(w)} q$ and $p \preceq^s_{g(w)} q$.)

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Supposing g' is updated from g (e.g. a simple update with $\{w_1, w_3\}$),

7. $g'(w) = \{\{w_1, w_3, w_4, w_5\}, \{w_1, w_2, w_3, w_4\}, \{w_1, w_3\}\}$
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8. $\textsc{Best}(f(w), g(w)) = \{w_1, w_3\}$

Conclusion: given f and g' relevant to the world w, $p \approx^s_{g'(w)} \neg p$

Interim conclusion

Definition (rules of graded modality (draft))

1. The degree of the possibility of a proposition p decreases, if the number of untied best p-worlds decreases.
2. The degree of the possibility of a proposition p increases, if the number of untied best p-worlds increases.

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Although I don't have a formal way to prove the above rules, but it is intuitively correct. An untied best world means there are some propositions in $g(w)$ are exclusive true in that world. More untied best worlds mean more ordering source propositions are exclusively true in those worlds. If p includes more such worlds, then p will satisfy more ordering source propositions exclusively. Hence, it will have better possibility. The same is true in decreasing cases.

With the help of the rules, we may define contextual evidence for $p/\neg p$ from the perspective of its belief updating power.

Definition (Contextual evidence (draft))

1. The degree of the possibility of a proposition p decreases, if the number of untied best p-worlds decreases.
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Is ordering source update enough?

Recall the previous *curtain* example, when a direct evidence for p is available in the context, the use of a *nandao*-Q induces a rhetorical reading and only the rhetorical reading. In those cases, the truth of p is certain.

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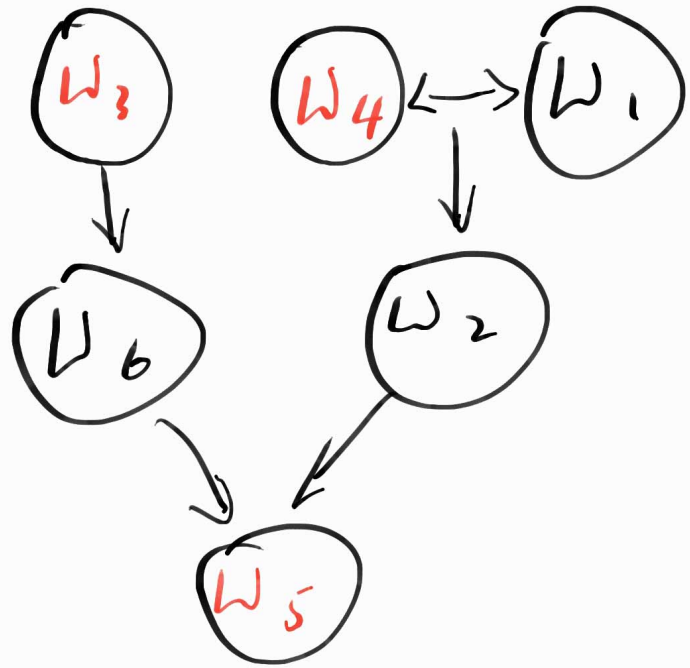
Recall the previous *curtain* example, when a direct evidence for p is available in the context, the use of a *nandao*-Q induces a rhetorical reading and only the rhetorical reading. In those cases, the truth of p is certain. To analyze this example, let's assume the following context,

Example

Context:

- $\bigcap f(w) = \{w_1, w_2, w_3, w_4, w_5, w_6\}$
- $p = \{w_3, w_4, w_5\}$ (= it isn't raining.)
- $\neg p = \{w_1, w_2, w_6\}$
- $g(w) = \{\{w_3, w_6\}, \{w_3\}, \{w_1, w_2, w_4\}, \{w_1, w_4\}\}$



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Example (Cont.)

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- Let $\mathrm{Con}(p) = \{\{w_5\}\}$ (As a piece of direct evidence for p, $\{w_5\} \subset p$)
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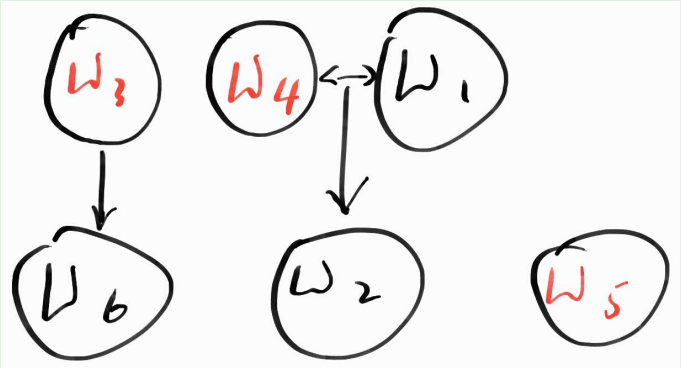

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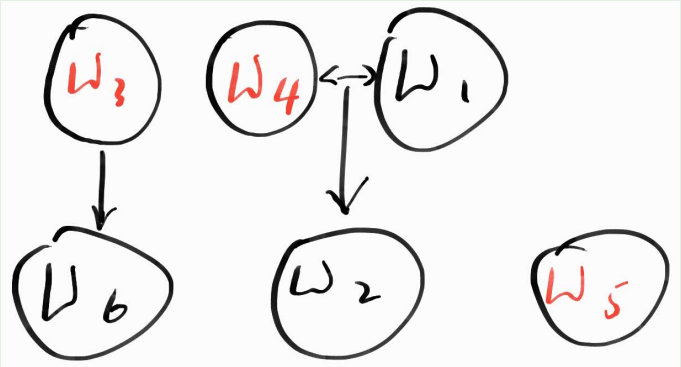

Although the possibility of p has been strengthened, $\neg p$ still has human possibility. Even when we promote all the p-worlds to be the only best worlds by updating the ordering source with $Con(p)$, $\neg p$ is still slightly possible. However, this is against our intuition of the truth of p in these cases. The failure tells us that a simple update of the ordering source cannot explain the RQ use of *nandao*-Q with direct evidence.

Simple necessity and simple possibility

As our intuition tells us that when the direct evidence is available in the context, the truth of p is undeniable[1], it means that $\neg p$ has no (simple) possibility to be true or it is just impossible for $\neg p$ in such a context. Kratzer (1981) defines such cases as simple necessity and simple possibility.

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Definition (Simple Necessity)

A proposition is a simple necessity in a world w with respect to the conversational background f if, and only if, it follows from $f(w)$.

Definition (Simple Possibility)

A proposition is a simple possibility in a world w with respect to the conversational background f if, and only if, it is compatible with $f(w)$.

So, our intuition about the above cases can be captured as,

Example

- $\neg\exists w(\forall q(q \in f'(w) \Longrightarrow q(w) = 1) \wedge p(w) = 0) \Longleftrightarrow \forall w \in \bigcap f'(w) : p(w) = 1$ (p is simple necessity)
- $\neg\exists w \forall q(q \in f'(w) \cup \{\neg p\} \Longrightarrow q(w) = 1) \Longleftrightarrow \neg\exists w \in \bigcap f'(w) : \neg p(w) = 1$ ($\neg p$ has no simple possibility)

Obviously, f' cannot be the given f in the context. It must be a new modal base derived from f. I propose that f' is updated from f by the following way,

Definition (Simple update of modal base)

$f^+(w) = f(w) \cup \mathrm{Con}(p/\neg p)$

Explain the RQ use of *nandao*-Q with direct evidence

Example

(Assuming the same p, $\neg p$, $f(w)$ and $g(w)$ in the previous case)

- Let $\mathrm{Con}(p) = \{\{w_5\}\}$,

Explain the RQ use of *nandao*-Q with direct evidence

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- and $f^+(w) = f(w) \cup \mathrm{Con}(p) \Longrightarrow \bigcap f^+(w) = \bigcap f(w) \cap \bigcap \mathrm{Con}(p) = \bigcap f(w) \cap p = \{w_5\}$.
- In this case, p has simple necessity:
  $p(w_5) = 1$, because $\forall w \in \bigcap f^+(w) : p(w) = 1$.

A comprehensive account of information-seeking use

With both the simple updates of the modal base and the ordering source, we can account for the information-seeking use of *nandao*-Q in cases like example (2).

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Context:

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- $p = \{w_3, w_4, w_5\}$, (= US troop shouldn't retreat from Afghanistan.)
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- then, $p \succ^s_{g(w)} \neg p$

A comprehensive account of information-seeking use

Supposing we have a piece of evidence against p,

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- $Con(\neg p) = \{\{w_1, w_2, w_3, w_4, w_6\}\}$

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- $Con(\neg p) = \{\{w_1, w_2, w_3, w_4, w_6\}\}$
- Thus, $g'(w) =$
  $\{\{w_3, w_6\}, \{w_3\}, \{w_1, w_2, w_4\}, \{w_1, w_4\}, \{w_5\}, \{w_1, w_2, w_3, w_4, w_6\}\}$

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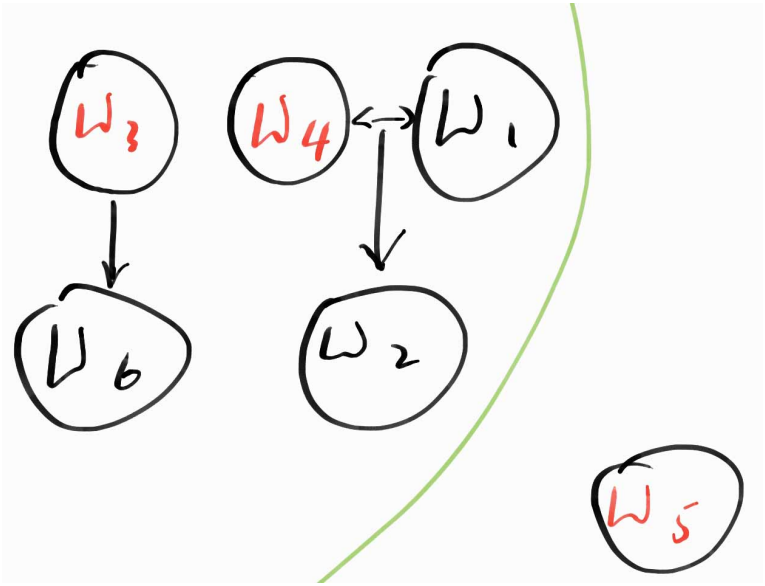
- and $\bigcap f^+(w) = \{w_1, w_2, w_3, w_4, w_6\}$ (shown on the left side of the green line in following figure)



Thank you!

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