Choosing a Logic to Represent the Semantics of Natural Language: Appendices

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In these appendices we provide the full validation of sentences that space precludes including in the published paper.

1   Appendix 1: SUMO Formalizations

Note that we repeat the first three formalizations from the main paper below, for completeness.

(corpus line 65640) neg: *Ministers were exploring several options to close that gap , but as talks dragged on Monday , no final solution appeared imminent .*

```
(exists (?M1 ?M2 ?N ?M)
  (and
    (attribute ?M1 GovernmentPerson)
    (attribute ?M2 GovernmentPerson)
    (not
      (equal ?M1 ?M2))
    (instance ?M Monday)
    (instance ?N Negotiating)
    (during ?N ?M)
    (agent ?N ?M1)
    (agent ?N ?M2)
    (not
      (expects ?M1
        (holdsDuring
          (ImmediateFutureFn
            (WhenFn ?N)
            (exists (?A)
              (and
                (instance ?A Agreement)
                (result ?N ?A)))))))
    (not
      (expects ?M2
        (holdsDuring
          (ImmediateFutureFn
            (WhenFn ?N)
            (exists (?A)
              (and
```

```
(instance ?A Agreement)
(result ?N ?A)))))))))
```

Note this sentence is already given in the text of the paper but the formalization is given here. Also to note is that we know from the plural 'Ministers' that there is more than one minister involved in the event. But we do not know that there are more than two involved. The logical form created with two different `GovernmentPerson`s in an `agent` relation requires two ministers, but does not entail that there are only two.

(corpus line 9632) author: *She said Gingrich conducted an affair with Callista Bistek his current wife " in my bedroom in our apartment in Washington " while she was elsewhere .*

```
(exists (?SAY ?WIFE)
  (and
    (agent ?SAY ?WIFE)
    (instance ?SAY Speaking)
    (containsFormula ?SAY
      (exists (?SR ?B ?A)
        (and
          (agent ?SR Gingrich)
          (agent ?SR CallistaBistek)
          (instance ?SR SexualReproduction)
          (instance ?B Bedroom)
          (instance ?A ApartmentUnit)
          (part ?B ?A)
          (located ?A WashingtonDCUnitedStates)
          (located ?SR ?B)
          (possesses ?WIFE ?A)
          (holdsDuring
            (WhenFn ?SR)
            (not
              (located ?WIFE ?A)))))))))
```

"She said..." creates the `containsFormula` relation between the `Speaking` event and the contents of the speaking, which is the formula that is the second argument to the relation. Another construct beyond FOL is `holdsDuring` which takes a temporal specification (of the time period of the liason) and formula that states the wife wasn't at the location of the liason while it occurred ("...she was elsewhere").

(corpus line 77220) quant: *But many dissidents have been less charitable , particularly about Ortega 's tacit acceptance of the government 's insistence that most freed political prisoners go into exile .*

```
(exists (?D)
  (and
    (attribute ?D Dissident)
    (disapproves ?D
      (not
        (exists (?E ?P)
          (and
            (instance ?E ExpressingDisappoval)
            (agent ?E Ortega)
            (refers ?E ?P)
            (containsFormula ?P
              (modalAttribute
                (=>
                  (and
                    (holdsDuring ?T
                      (and
                        (attribute ?P Prisoner)
                        (citizen ?P ?C)
                        (attribute ?P Dissident)))
                    (holdsDuring
                      (ImmediateFutureFn ?T)
                      (and
                        (not
                          (attribute ?P Prisoner)))))
                  (holdsDuring
                    (ImmediateFutureFn ?T)
                    (attribute ?P Expellee)))
                Obligation))))))))
```

There is still more to say here, but this formalization is already beyond even modal FOL in expressiveness. We take "...less charitable..." as a statement that a `Dissident` `disapproves` of Ortega's actions. We also see the relation `modalAttribute` that makes a statement of `Obligation` ("...that most freed political prisoners go into exile..."

```
(exists (?H ?S ?C)
  (and
    (instance ?C Election)
    (agent ?C ?H)
    (instance ?S Speaking)
    (agent ?S ?H)
    (containsFormula ?S
      (exists (?O)
        (and
          (instance ?O OlympicGames)
          (increasesLikelihood
            (attribute ?O SubjectiveStrongPositiveAttribute)
            (electionWinner ?C ?H)))))))
```

"...he says..." means there is a `Speaking` that `containsFormula` that if the Olympics has a positive attribute (which can be taken from the "success" of the Olypics) then that `increasesLikelihood` of the speaker being the `electionWinner`.

(corpus line 53967) neg: *" I never , ever got over it , " Cain says , her voice shaking .*

```
(exists (?S)
  (and
    (instance ?S SpeakingWithTremblingVoice)
    (agent ?S Cain)
    (containsFormula ?S
      (not
        (exists (?T)
          (and
            (holdsDuring ?T
              (not
                (disapproves Cain
                  (exists (?IT)
                    (and
                      (instance ?IT Process)
                      (earlier
                        (WhenFn ?IT)
                        ?T)
                      (inScopeOfInterest ?IT Cain)))))))))))
```

Cain's "...shaking..." voice says that there was something in the past that she `disapproves` of.

2   Appendix 2: Sentence-level Validation

In corpus sentence examples below we provide comment on the logic required (as determined by the automatic classification method) but not a full formalization. Note that in the original corpus some sentences are grouped together, rather than fully segmented and the line number in the table is for the start of the group.

88218	neg	*Pressed on whether Bales can remember anything about the shooting , Browne said , " No , " but added : " ... "*	negation as well as authorship ("...Brown said...")
80089	epistemic	*She said he feels that his life really began when he retired from the ring .*	authorship ("She said..."). [1]
614	modal	*Islamist backers of Iran could target civilians all over the world .*	(..."could"...) expresses modal possibility [2]
71235	author	*" I was going to be spending a lot of time in D.C. , " Romney wrote in his book about the games , called " Turnaround . "*	"...wrote..." entails authorship.
18397	neg	*The women and the kids would like to join them , but many do n't have enough money .*	hypothetical they "would like to" if they had enough money, but "many" (a quantifier), do not "have enough money" Each one of these three constructs requires at least FOL.
74998	epistemic	*Within the last week , authorities say , Amine El Khalifi 's plan to wreak havoc was proceeding as hoped : An al-Qaida associate handed him an automatic weapon to kill security officers inside the U.S. Capitol .*	El Khalifi "hoped" that (formula...) the plan would wreak havoc.
2389	author	*Following a two-hour meeting later that night in which Dambly said the trustees came to a consensus , vice chair John Surma had an assistant athletic director relay a message to Paterno 's home to call him .*	Both "Dambly said..." and "relay a message..." (that contains a formula) require HOL.
56751	modal	*" All of these things the president talks about can be done at the local and state level , and are being done at the local and state level , " Foxx said . "*	The sentence has a modal "...can..."
19407	neg	*Not no much can be done against those men , " he said , referring to al-Shabab , " because they penetrated the camp , so no one can stop them .*	It looks like the initial part of the sentence has a typo and could be "Not too much..." or "Not so much..." but there's also a later negation "...no one can stop them" as well as the modal statement of possibility "...can..."
45828	quant	*These are all kids coming from rich families or good families , and they 're just trying to make a living , have a good career , have a good college experience .*	"...all kids..." quantifying over a disjunction
4410	neg	*" @ @ @ @ @ @ @ @ @ @ did n't play defense .*	There is elided text, but there is still a clear negation.
44055	author	*Kelly and New York City Mayor Michael Bloomberg repeatedly have said that the police only follow legitimate leads about suspected criminal activity .*	"..repeatedly said..." there's more than one `Saying` that `containsFormula` that "...police only follow...." HOL is required
31347	modal	*It also could anger people across the Arab world fighting to oust corrupt and authoritarian rulers .*	"...could anger..." entails a modal operator.
13729	author	*Firefighters had zero containment of the blaze and were concentrating on using crews and trucks to protect homes in the path of the flames , Hernandez said .*	"...Hernandez said." requires authorship.
68444	quant	*With Moreno , trainers , coaches and instructors watching , Pujols ripped a few fastballs from hitting coach Mickey Hatcher for line drives and then launched a deep shot over @ @ @ @ @ @ @ @ @ giant palm trees and disappearing into the brush .*	"...a few fastballs..." is a quantifier.
55781	neg	*During his State of the Union address , Obama put the higher education on notice : " If you ca n't stop tuition from going up , the funding you get from taxpayers will go down , " he said . "*	"...if you can't..." requires negation, and also a hypothetical conditional.
46583	author	*He said that in its latest round , the company borrowed 500,000 yuan ($80,000) in July and repaid it two months later with 2 percent monthly interest .*	"He said..." requires authorship.
58261	neg	*The Vests are hoping for a long sentence either on the Pennsylvania charges or a probation violation in the Booth case , because they do n't expect even an explanation for what she did to them .*	"...don't expect..." negating a complex expression "...even an explanation for what she did to them." Also "...hoping for..."
9599	epistemic	*In an interview scheduled to air on ABC News , Marianne Gingrich said her ex-husband had wanted an " open marriage " so he could have both a wife and a mistress .*	"...Gingrich said..." authorship, also the operator "...wanted..."
75448	neg	*She had a job , but El Khalifi appeared not to have rent money .*	"...not to have..." negation, and also the epistemic "...appeared..."

line	type	text	notes
19965	modal	*The judge granted the media access , and ruled that the four would remain in custody until a second hearing Monday .*	"...would..." is really a normative operator, saying that the state has an obligation to confine "the four". Also "...ruled..." is an authorship statement.
87268	neg	*More than $6 billion more has been identified but not yet secured .*	"...not yet secured" negation. If the negation were simply modifying "secured" it's possible we could have a formalization in description logic where a class of unsecured funds is defined. However, in this case, the inclusion of "yet" implies that there is a possibility that the funds will be secured, which requires a modal operator.
51411	epistemic	*Thirty-two years later , Australian officials hope to finally , definitively , determine how Azaria died when the Northern Territory coroner opens a fourth inquest on Friday (Feb. 24) .*	"...hope..." is an epistemic operator
52827	quant	*" The church got so smashed up , erroneously , and all through , really , a nasty dose of prejudice , " Chamberlain says . "*	"...all through..." the church there was "smashing" entails quantification. Also authorship - "Chamberlain says"
785	neg	*While Israel is unlikely to strike without coordinating @ @ @ @ @ @ @ @ @ aircraft carriers and military bases in the Gulf , Israeli officials will not make any promises to Dempsey , the officials said .*	"...will not..." is a negated intention for the future. "unlikely" is an expression of probability about a formula becoming true. This is something that could be added to our word list, as "likely", "unlikely", "rare", "frequent" are similar in the logical requirements
88175	quant	*He has some memories of before the incident and he has some memories of after the incident .*	"...some memories..." is existential quantification.
76654	quant	Dissidents , U.S. diplomats and even some Vatican power brokers have disparaged the cardinal 's cautious approach , saying he often seems more concerned with church renovations than with human and political rights .	"...some Vatican..." existential quantification. Also "...saying..." authorship
66851	neg	" One of the people I 'm running against , Sen. Santorum , goes to Washington and calls himself a budget hawk @ @ @ @ @ @ @ @ @ @ 's no longer a budget hawk , " Romney said . "	"...Romney said." authorship
61548	epistemic	Fearing the shift , Detroit decided to go after the Japanese and shifted research dollars from trucks @ @ @ @ @ @ @ @ @ @ that Hondas and Toyotas were quieter and more reliable , so they spent more on engineering and parts to close the gap .	"...decided..." epistemic. They had a plan or intention to [compete with Japanese businesses that also made and sold cars], which is a formula.
41409	epistemic	I still feel like I have the physical and intellectual capacity to serve my people . "	"...feel like..." statement of belief wrapping a statement of capability
72999	modal	Romney is favored although the delegates could be divided .	"...could be..." a statement of possibility. The notion of "favored" is also a statement about the probability of a formula
50650	neg	In most years , it does n't matter because the party nominee is obvious by then , so the presumptive nominee gets all the delegates , regardless of who won in January .	"...doesn't matter" is negation of a formula. There's also an implied normative statement that election rules requires that the presumptive nominee get the delegates. Also quantification ("...all the delegates...")
63888	neg	With unions no longer in a strong position to fight for benefits like pensions , with jobs disappearing or going overseas , and with Gen Xers and even younger Millennial Generation members coveting their jobs , Lawler warns this is no time for boomers to quit and allow the skills they 've spent a lifetime building to atrophy.	"...no time..." negation. Also a statement of probability with another negation "...no longer in a strong..." Also "...Lawler warns..." is authorship
89291	author	That expert said charges were still being @ @ @ @ @ @ @ @ @ @ yet been determined .	"...expert said..." authorship
49024	neg	For Greeks , this is a matter of national dignity and a national strategic choice and no other integrated and responsible choice can be opposed to it . "	"...no other..." negation. Also attributes a belief (epistemic) to Greek citizens
14523	modal	The storm also raised worries that flooding could become a broader concern in days to come .	"...could..." modal. Also "...raised worries..." is a statement of belief in the probability of an undesirable event
62804	epistemic	Symons , fresh out of college , entered this brave new world thinking she 'd do pretty much what her parents generation did : Work for just one or two companies over about 45 years before bidding farewell to co-workers at a retirement party and heading off into her sunset years with a pension .	"...thinking..." epistemic.

34499	neg	Fans can only marvel at what they see on the court : a rotation of 10 players , and unlike the bickering on Boeheim 's only national championship team in 2003 not a single frown .	"...not a single frown..." negated quantification. Also a statement of thought about a formula - "...marvel at..."
89341	epistemic	After their investigation , military attorneys could draft charges and present them to a commander , who then makes a judgment on whether there is probable cause to believe that an offense was committed and that the accused committed it .	"...could draft..." modal wrapping a statement of probability "...probable cause..." wrapping an epistemic "...believe..."
35937	author	" The water is clean and the reefs are rich " for fish to feed , she said , as trucks carrying oil-removal equipment waited to board ferries to Giglio . "	"...said..." authorship
8939	author	Let me be clear , the story is false , " he said .	"...said..." authorship. Also a statement that another authored statement is not true.
85752	author	" If we 're able to come out of Illinois with a huge or surprise win , I guarantee you , I guarantee you that we will win this nomination , " Santorum said .	"...said" authorship. Also a statement of belief in a hypothetical future
60490	modal	Defense Minister Ehud Barak has estimated that an Iranian attack would claim fewer than 500 Israeli casualties a statement intended to calm the nation , but which has achieved the opposite effect .	"...would claim..." modal. Also authorship "...Ehud Barak has estimated..."
56553	quant	His administration has expanded the availability of Pell grants , supported a tax credit for tuition costs and is attempting to make it easier for some graduates to pay back loans .	"...some graduates..." quantification, and this is wrapped in an expression of intent "...attempting to make..."
57679	neg	But even the officer who called the Vests , Greg Koprivnak , acknowledged , " To be quite honest with you , there 's no statue that deals with this kind of behavior. "	"...there's no...." negation. Also "...acknowledge..." is a statement of authorship
42027	modal	And while many families can afford to eat only once a day , members of the ruling party drive over potholed streets in the latest BMW X series .	"...can afford..." modal
15525	neg	Karina @ @ @ @ @ @ @ @ @ an emergency declaration has been issued , the National Guard has not been called up .	"...has not been..." negation
76654	quant	Some even see him as an apologist for the government that once imprisoned him .	"...some..." quantification. Also "...see him as..." is a statement of belief.
86919	author	" Stick with us , " he said .	"...he said..." authorship
75376	neg	In 2010 , he aroused the suspicion of a former landlord @ @ @ @ @ @ @ @ @ @ inside a brick building in Arlington before ultimately evicting him for not paying rent .	"...not paying rent." negation. There's also an expression of causality "...evicting him for..." which could be modeling in first order if the cause and effect are simple attributes of events, but not if they are complex logical expressions.
5072	epistemic	A loose affiliation of hackers known as " Anonymous " claimed credit for the attack .	"...claimed..." is actually a statement of authorship rathen than belief, but still higher order
65640	neg	Ministers were exploring several options to close that gap , but as talks dragged on Monday , no final solution appeared imminent .	"...no final solution..." negation
62420	author	But that has pretty much evened out , he said .	"...he said." authorship.
57317	neg	Slanina never asked for money and knew exactly what to say , Rebecca said .	"...never asked..." is negation but more expressive since it's saying that she didn't ask for a formula. So it's a sort of negative authorship, and that in turn is wrapped in another authorship "...Rebecca said."
9878	modal	Santorum ran commercials likening Romney to Obama ; Gingrich 's cast the former speaker as the only candidate who could defeat the president this fall .	"...could defeat..." modal. The commercials also have an authored content "...likening Romney to Obama..."
79863	quant	When Ali converted to Islam , many people resisted calling him by his new name .	"...many people..." quantification. "...resisted..." also is a statement of intent over a formula.
27965	neg	It is not the first time that an Afghan soldier ... assassinates French soldiers , " Foreign Minister Alain Juppe said .	"...not the first time..." negation and also "...said." authorship.

85531	quant	Romney has spent big on advertising and will have devoted more than three straight days to the state an eternity by some standards in this constantly shifting campaign by the time votes are counted Tuesday night .	"...some standards..." quantification.
89291	modal	If the suspect is brought to trial , it is possible that Afghan witnesses and victims would be flown to the U.S. to participate , he said .	"...he said." authorship. "...would be flown..." modal
4600	epistemic	" But another thing I learned playing the game that long @ @ @ @ @ @ @ @ @ @ play , " and here Junkin dragged out the words for emphasis , " as a team . "	X The elision makes full analysis impossible
45258	modal	The escrow account would , however , be an unprecedented intrusion into a sovereign state 's fiscal affairs and could ultimately see Greece forced to pay interest on its debt before paying salaries to teachers and doctors .	"...account would..." modal. Also "...could ultimately..."
33366	modal	Erickson , who plans to step down in 2014 , also said the university " must always be mindful of the need for institutional humility , integrity and resolve ... Let us seek balance in our words and deeds . "	"...must always..." is really a statement of normative force, stating a moral obligation about a formula
13349	author	" Several " homes had been destroyed before nightfall Thursday , Hernandez said .	"...said." authorship. "Several..." is quantification
43133	modal	His clinic has worked with local surgeons who 've done breast removal surgery on girls at age 16 , but that surgery can be relatively minor , @ @ @ @ @ @ @ @ @ @ he said .	"...can be..." modal
11511	author	He said Congress moved to require visa applicants to be interviewed as a result .	"...said..." authorship
1486	epistemic	" We have lots of things that we need to do in terms of the board and how it operates , and I think you 'll see some positive things come out of that , " trustee Mark Dambly said Thursday .	"...said..." is an authorship which wraps a statement of prediction about knowledge "...you'll see..."
19158	author	Elmi Addow , a farmer in the Hiran region , said : " My farm is in the final stages before harvesting the crops .	"...said..." authorship
81691	epistemic	Patek had shown intense passion for jihad , or holy war , in his homeland and in the southern Philippines , and it was strange that he would suddenly decide to go to an unfamiliar destination like Afghanistan , said the official , who was closely associated with the manhunt for Patek.	"...decide..." epistemic, which is also wrapped in an expression of authorship "...said the official..."
43473	modal	" It would be so nice to move this out of the world of mental health , and into the medical world , " Olson said .	"...would be..." modal, wrapped in authorship - "...Olson said"
82191	author	Badar and another man who identified himself as Haidar , took Patek and his wife to Abbottabad in January 2011 , he said .	"...he said." authorship
5267	quant	We have some good ideas .	"...some..." quantification, although one could make a case that this could be done in DL if we define a class of "good ideas"
541	modal	Islamist backers of Iran could target civilians all over the world .	"...could..." modal
67003	author	He said government has accumulated power " by weakening the institutions that people rely upon in their lives . "	"He said..." authorship
86665	modal	The New York Mets owners scored an early-season victory Monday , stabilizing the club 's financial future in a deal with a trustee for Bernard Madoff 's fraud victims that requires them to pay millions less than they might have and lifts a dark cloud from a team whose dismal play seemed to mirror its misfortune in the owner 's box .	"...might have..." modal. "...seemed..." is also an epistemic
75464	author	He looked terrible on paper , " Dynda said .	"...said." authorship
75702	neg	The FBI does n't believe he was conspiring with anyone else , and court documents in El Khalifi 's case do n't give further details about the meeting in the Arlington apartment and the other people who were there .	"..doesn't..." is negation and that wraps an epistemic "...believe..."
79990	author	That changed over time , he said .	"...he said" - authorship
83065	epistemic	In the end , though , Manning decided he wanted to trade in his Colts horseshoe helmet for one adorned by a Bronco .	"...decided..." is an epistemic, which wraps another epistemic "...wanted..."

53666	neg	Perhaps no one exemplifies the shifting opinions , uncertainty and nagging guilt of Australians more than Yvonne Cain , one of @ @ @ @ @ @ @ @ @ @ , she empathized with the woman on trial : Cain 's own son was bitten by a dingo when he was just a baby .	"...no one..." is actually a quantifier rather than a negation.
71528	author	Now Governor Romney @ @ @ @ @ @ @ @ @ @ Santorum said . "	"...Santorum said." authorship
27232	epistemic	The impact of the French suspending training operations is unclear , but it would result in a major setback for the U.S.-led coalition if other troop-contributing nations stopped training Afghan national security forces or decided to pull out earlier than planned .	"...decided..." epistemic.
60490	modal	Defense Minister Ehud Barak has estimated that an Iranian attack would claim fewer than 500 Israeli casualties a statement intended to calm the nation , but which has achieved the opposite effect .	"...would..." modal, wrapped in an authorship "...estimated..." Also an expression of causality "...effect."
71036	author	" There is a pretty wide gulf between seeking money for post-9/11 security at the Olympics and seeking earmarks for polar bear exhibits at the Pittsburgh Zoo , " spokeswoman Andrea Saul said in a statement , taking a dig at Santorum , a former Pennsylvania senator . "	"...said..." authorship, also "...seeking..." stating a desire for an object (money) to be put to a purpose, which is a formula
41253	other modal	To be able to have run after the horse , Niasse says Wade needed to be at least four , meaning that he was born in 1922 like his classmate Aw .	"...needed..." is a modal. This is actually stating a deductive argument. There's also the authorship of "...Niasse says..."
3556	epistemic	" Do I want to get back in ?	"...want..." epistemic
55848	neg	He wants to slightly reduce federal aid for schools that do n't control tuition costs and shift it to those that do .	"...don't control..." negation, also "...want..." epistemic
5471	neg	Megaupload was unique not only because of its massive size and the volume of downloaded content , but also because it had high-profile support from celebrities , musicians and other content producers who are most often the victims of copyright infringement and piracy .	"...not only..." is marked as a negation, although this could be modeled as a positive statement. However there's also a statement of probability "...most often..."
17982	quant	Karlovic was a point from forcing a second-set tiebreaker but Federer stepped it up , earning two set points with some trademark backhands and converting on the second when the tall Croatian netted a volley .	"...some..." quantification. Also an interesting case of talking about an event which doesn't exist and never will "...second set tiebreaker"
6430	epistemic	The testing , to be carried out over the next several weeks , marks a significant expansion of the agency 's probe in Dimock , a tiny crossroads at the center of a national debate over gas drilling and the extraction technique known as hydraulic fracturing , or fracking.	X "...known..." in this case is not an epistemic but just an expression of synonymy. If we create a class of Fracking one could have a simple relation of "communicationAbout" that would relate a communication event "...debate..." and a class representing a topic, so it's possible this could be done in a description logic.
77464	epistemic	On issues large and small , Catholic Church strategy is to capitulate to GOC positions , preemptively @ @ @ @ @ @ @ @ @ @ , Ortega 's role in freeing the dissidents has become known , critical articles are reappearing in church magazines and the cardinal is more publicly supportive of the Ladies in White opposition group .	"...known..." epistemic. Also the specification of a "...strategy..." or intent would require HOL.
88566	neg	The details of the blast could not be immediately confirmed .	"...could not..." negation. Beyond that, it is talking about an epistemic as there is information that the reporter wants and he or she is not yet able to get that information.
6430	neg	" I ca n't even tell you , again , what a relief this is.	X Read literally, "...can't tell..." is a negation but it isn't since later in the sentence the speaker does tell the listener what he or she wants to say, that [it] is a "relief". It's just a politeness construct. If the referent of "it" is a complex statement that would have to be modeled as a formula, then this is HOL. But if it's just an event, then it could be represented in FOL or even DL
46947	author	Zhang , the schoolteacher in Anyang in the central province of Henan , said she lent money last March to five local companies after friends put her in touch with the owners .	"...said..." authorship