KING ARTHUR & THE CONTEXT FREE GRAMMARS

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SENTENCES

SENTENCE 1
Arthur is the king.
CHANGES – are in bold

```
#   Verb phrases
VP -> VerbT NP

#   Noun phrases
NP -> Proper | Det NP | NN
```

RESULT

['Arthur', 'is', 'the', 'king', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP (VerbT is) (NP (Det the) (NP (NN king))))
    (Eos .)))

Since the rules for the sentence are NP VP Eos, the parser will parse Arthur (the noun phrase). Arthur is a proper noun and is tagged as Proper. "is the king" is a VP that contains a NP. "is" is a transitive verb with is tagged VerbT. "the king" is a noun phrase that is nestled in the verb phrase, therefore we added VerbT NP to the rules for VP. The last part of the sentence that we needed to parse is "the king" the is a determiner (Det) and king is a noun (NN). Therefore, Det NN was added to the rules for NP. However, we know that it is likely that Det will have other noun phrases that follow it and we decided to add two new rules Det NP and NN for NP. This way when the parser runs it will find Det NP and then go back to match the correct NP that follows Det.

SENTENCE 2

SENTENCE 2

Arthur rides the horse near the castle.

CHANGES – are in bold

```
#  Verb phrases
VP -> VerbT NP |


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP |
```

RESULT

```
['Arthur', 'rides', 'the', 'horse', 'near', 'the', 'castle', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP
      (VerbT rides)
      (NP
        (Det the)
        (NP
          (NN horse)
          (PP (Prep near) (NP (Det the) (NP (NN castle)))))))
    (Eos .)))
```

 We did not need to add anything for the first NP ("Arthur") as the Proper tag is already accounted for in NP. The VP is "rides the horse near the castle", rides is tagged as a VerbT and is followed by a NP which is already accounted for; therefore, we did not need to add anything to the parser. "the horse near the castle" is the NP that follows VerbT. We needed to add NN PP to parse "horse near". The rest of the sentence will be parsed with the rules previously implemented.

SENTENCE 3

Arthur rides the plodding horse near the castle.

CHANGES

```
#  Verb phrases
VP -> VerbT NP |


#  Noun phrases
```

```
NP -> Proper | Det NP | NN | NN PP |JJ NN PP
```

['Arthur', 'rides', 'the', 'plodding', 'horse', 'near', 'the', 'castle', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP
      (VerbT rides)
      (NP
        (Det the)
        (NP
          (JJ plodding)
          (NN horse)
          (PP (Prep near) (NP (Det the) (NP (NN castle)))))))
    (Eos .)))

The only difference in this sentence from sentence 2 is the adjective "plodding". We added the NP rule JJ NN PP to catch "plodding horse near", because we already have the rule Det NP, we do not need to include Det in the new rule. We created the JJ tag for adjectives.

The Holy_Grail is a chalice.

```
#  Verb phrases
VP -> VerbT NP


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP |JJ NN PP | NNP
```

['the', 'Holy_Grail', 'is', 'a', 'chalice', '.']
(START
  (S1
    (NP (Det the) (NP (NNP Holy_Grail)))
    (VP (VerbT is) (NP (Det a) (NP (NN chalice))))
    (Eos .)))
```

The sentence has a very similar structure as the previous sentences. The only rule that we need is a rule for "Holy_Grail" which is a proper noun, that does not refer to a person. We named this tag NNP. By adding NNP as a NP rule, the parser will catch "the Holy_Grail" as a NP, by first catching Det NP and then going back and looking for a NP that matches "Holy_Grail".

## SENTENCE 5

the sensational Holy_Grail is a sacred chalice.

### CHANGES

```
#  Verb phrases
VP -> VerbT NP


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | JJ NN NP | NNP | JJ NNP | JJ NP
```

RESULT

['the', 'sensational', 'Holy_Grail', 'is', 'a', 'sacred', 'chalice', '.']
(START
  (S1
    (NP (Det the) (NP (JJ sensational) (NP (NNP Holy_Grail))))
    (VP (VerbT is) (NP (Det a) (NP (JJ sacred) (NP (NN chalice)))))
    (Eos .)))

The only difference between this sentence and the previous one is the addition of the adjective sensational". Therefore, we needed to include a rule that had JJ NNP. At this stage, we noticed that we could create a rule JJ NP to help reduce the number of rules created. The rules that were deleted are highlighted in red.

SENTENCE 6

every coconut was carried to the hottest mountains

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS
```

['every', 'coconut', 'was', 'carried', 'to', 'the', 'hottest', 'mountains', '.']
(START
  (S1
    (NP (Det every) (NP (NN coconut)))
    (VP
      (VBD was)
      (VBN carried)
      (NP (TO to) (NP (Det the) (NP (JJS hottest) (NNS mountains)))))
    (Eos .)))

The noun phrase "every coconut" will be parsed with the existing rules. However, we need to add new rules for the verb phrase "was carried to the hottest mountains". "was" is a past tense verb which we labeled as VBD. "carried" we determined was a past participle, which we labeled as VBN. We created the following VP: VBD VBN NP. The noun phrase is "to the hottest mountains." "to" is tagged as TO, "hottest" is a superlative adjective which we labeled as JJS and mountains is a plural noun tagged as NNS. Therefore we needed to add two more rules to NP: TO NP and JJS NNS.

sixty strangers are at the Round_Table.

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS | CC
NP | NNS
```

['sixty', 'strangers', 'are', 'at', 'the', 'Round_Table', '.']
(START
  (S1
    (NP (CD sixty) (NP (NNS strangers)))
    (VP
      (VBP are)
      (PP (Prep at) (NP (Det the) (NP (NNP Round_Table)))))
    (Eos .)))

This sentence starts out with a NP that begins with a number, which we tagged as CD. We added two tags for the NP "sixty strangers". The first tag was CC NP and the second was NNS. We decided to approach it this was in case we had additional NP that started with CC, CC NP should take care of this, as long as we have a NP rule to match what follows CC. We had to add NNS because we did not have a rule solely for NNS. The VP "are at the Round_Table", also required a new rule. "are" is a present, plural, third person verb tagged as VBP it is followed by a prepositional phrase "at the Round_Table". The rest of the sentence already conforms the existing rules.

SENTENCE 8

Sir_Lancelot might have spoken.

CHANGES

```
# Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN

# Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS | CC
NP | NNS
```

RESULT

```
['Sir_Lancelot', 'might', 'have', 'spoken', '.']
(START
  (S1
    (NP (Proper Sir_Lancelot))
    (VP (MD might) (VP (VBP have) (VBN spoken)))
    (Eos .)))
```

We do not have to add a rule for the NP, however we do need to add a new rule for the VP. "might" is a modal verb that we tagged as MD. We decided to create two rules for this: MD VP, and then we need VBP VBN to parse "have spoken" this way, we might not have to generate as many rules.

SENTENCE 9

Guinevere had been riding with Patsy for five weary nights.

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS | CC
NP | NNS | Proper PP
```

RESULT

['Guinevere', 'had', 'been', 'riding', 'with', 'Patsy', 'for', 'five', 'weary', 'nights', '.']
(START
  (S1
    (NP (Proper Guinevere))
    (VP
     (VBD had)
     (VBN been)
     (VBG riding)
     (PP
      (Prep with)
      (NP
       (Proper Patsy)
       (PP
        (Prep for)
        (NP (CD five) (NP (JJ weary) (NP (NNS nights))))))))))
    (Eos .)))

No new rules were needed for the initial NP. A new rule was added for the VP. "had been riding with Patsy for five weary nights". In order to parse "had been riding with" the following rule was created: VBD VBN VBG PP. "with Patsy" will be parsed with the current rules, however a new rule needed to be added for a PP to follow a Proper noun. Therefore, Proper PP was included in the rules. The rest of the sentence will be parsed with our current rules.

SENTENCE 10

Sir_Bedevere might have been suggesting this quest.

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP
```

```
#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS | CC
NP | NNS | Proper PP
```

['Sir_Bedevere', 'might', 'have', 'been', 'suggesting', 'this', 'quest', '.']
(START
  (S1
    (NP (Proper Sir_Bedevere))
    (VP
      (MD might)
      (VP
        (VBP have)
        (VBN been)
        (VBG suggesting)
        (NP (Det this) (NP (NN quest)))))
    (Eos .)))

The initial NP "Sir_Bedevere" does not require any additional rules. The new rule that was
needed is VBP VBN VBG NP this ensures that " might have been suggesting this quest" is
parsed.

the Britons migrate south frequently.

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS
```

['the', 'Britons', 'migrate', 'south', 'frequently', '.']
(START
  (S1
    (NP (Det the) (NP (NNPS Britons)))
    (VP (VBP migrate) (RB south) (RB frequently))
```

```
    (Eos .)))
```

A new rule was created to capture the first NP "the Britons". "Britons" is a plural proper noun that was given the tag NNPS. The VP also needed a rule generated. "migrate south frequently" is comprised of VBP and two adverbs. We gave adverbs the RB tag.

Arthur and Guinevere ride frequently near the castle.

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper NP
```

RESULT

```
['Arthur', 'and', 'Guinevere', 'ride', 'frequently', 'near', 'the', 'castle', '.']
(START
  (S1
    (NP (Proper Arthur) (NP (CC and) (NP (Proper Guinevere))))
    (VP
      (VBP ride)
      (RB frequently)
      (PP (Prep near) (NP (Det the) (NP (NN castle)))))
    (Eos .)))
```

To parse "Arthur and Guinevere" the first NP, a new rule was generated: Proper NP. A new rule was also necessary to parse the VP " ride frequently near the castle". "ride frequently near" was parsed with VBP RB PP. No new rules were needed for "the castle".

he suggests to grow fruit at home.

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP
```

['he', 'suggests', 'to', 'grow', 'fruit', 'at', 'home', '.']
(START
  (S1
    (NP (PRP he))
    (VP
      (VBZ suggests)
      (TO to)
      (VB grow)
      (NP (NN fruit) (PP (Prep at) (NP (NN home)))))
    (Eos .)))

A new rule was generated for the initial NP "he". "he" is a personal pronoun was we tagged it as PRP. A new rule was also necessary to parse the VP "suggests to grow fruit at home". "suggests" is a third person singular verb and we gave it the tag VBZ. "grow" is also in its base form and we gave it the tag VB. No new rules were needed to parse the PP "at home".

riding to Camelot is not hard.

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP
```

['riding', 'to', 'Camelot', 'is', 'not', 'hard', '.']
(START
  (S1
    (NP (VBG riding) (NP (TO to) (NP (NNP Camelot))))
    (VP (VerbT is) (NOT not) (JJ hard))
    (Eos .)))

A new rule was generated for the NP "riding to Camelot". "riding" is considered a gerund or present participle it given the tag VBG. "to Camelot" is already parsed with our existing rules; therefore, the new rule is VBG NP. The VP also needed a new rule to parse "is not hard" is made of a VerbT NOT and JJ

do coconuts speak?

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP


#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP
```

['do', 'coconuts', 'speak', '?']
(START
  (S1 (NP (DO do) (NP (NNS coconuts))) (VP (VBP speak)) (Eos ?)))

A new rule was generated for the initial NP "do coconuts". "do" is tagged with DO. This has not been accounted for in the rules yet; therefore, we added the following rule DO NP. A new rule was also generated for the VP "speak" no rule previously existed for a singular VBP with nothing else following it.

why does England have a king?

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP
```

RESULT

```
 ['why', 'does', 'England', 'have', 'a', 'king', '?']
(START
  (S1
    (NP (WRB why) (NP (DO does) (NP (NNP England))))
    (VP (VBP have) (NP (Det a) (NP (NN king))))
    (Eos ?)))
```

A new rule was needed for the first NP "why does England". "why" is a wh-adverb and given the WRB tag. There are already rules written that will parse "does England" therefore the new rule only included WRB NP. A new rule was also needed for the VP "have a king". There were no rules for a NP to follow VBP.

All original sentences were successfully parsed with only one tree per sentence.

Challenge Sentences

SENTENCE 17

What horse does Arthur ride?

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP
```

```
#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP
```

RESULT

['what', 'horse', 'does', 'Arthur', 'ride', '?']
(START
  (S1
    (NP
      (WDT what)
      (NP (NN horse) (NP (DO does) (NP (Proper Arthur)))))
    (VP (VBP ride))
    (Eos ?)))

A new rule was generated to capture "what" in the initial NP. In this situation "what" is acting as a WH determiner and was given the tag WDT. A second rule was added for the initial NP for "horse does Arthur" we needed a NN NP to parse this.

SENTENCE 18

who does Arthur suggest she carry?

CHANGES

```
#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP
```

RESULT

['who', 'does', 'Arthur', 'suggest', 'she', 'carry', '?']
(START
  (S1
    (NP (WP who) (NP (DO does) (NP (Proper Arthur))))
    (VP (VBP suggest) (NP (PRP she) (VP (VBP carry))))

```
   (Eos ?)))
```

A new rule was generated for the initial NP "who does Arthur". "who" is a wh pronoun and has the tag WP. Since there are already rules that will parse "does Arthur" in the NP rules, the new rule is WP NP. A new rule was also needed in the VP "suggest she carry". The NP "she carry" needed the following rule PRP VBP to parse it.

SENTENCE 19

are they suggesting Arthur ride to Camelot?

CHANGES

```
# Sentences
S1 -> NP VP Eos | VP NP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP
```

RESULT

```
['are', 'they', 'suggesting', 'Arthur', 'ride', 'to', 'Camelot', '?']
(START
  (S1
    (VP (VBP are) (NP (PRP they)))
    (NP
      (VBG suggesting)
      (NP
        (Proper Arthur)
        (VP (VBP ride) (NP (TO to) (NP (NNP Camelot))))))
    (Eos ?)))
```

--- The two sentences where additional parse trees were created as a byproduct of the new rules
_
['what', 'horse', 'does', 'Arthur', 'ride', '?']
(START
 (S1
  (NP
   (WDT what)
   (NP (NN horse) (NP (DO does) (NP (Proper Arthur)))))
  (VP (VBP ride))
  (Eos ?)))
(START
 (S1
  (NP
   (WP what)
   (NP (NN horse) (NP (DO does) (NP (Proper Arthur)))))
  (VP (VBP ride))
  (Eos ?)))
['who', 'does', 'Arthur', 'suggest', 'she', 'carry', '?']
(START
 (S1
  (NP (WP who) (NP (DO does) (NP (Proper Arthur))))
  (VP (VBP suggest) (NP (PRP she) (VP (VBP carry))))
  (Eos ?)))
(START
 (S1
  (NP
   (WP who)
   (NP
    (DO does)
    (NP (Proper Arthur) (VP (VBP suggest) (NP (PRP she))))))
  (VP (VBP carry))
  (Eos ?)))

We had to include an optional sentence structure VP NP Eos to account for this question. The only other new rule that was needed was to account for the NP "Arthur ride to Camelot" this was parsed by adding a rule for Proper VP. However, in doing this two additional parse trees were created for previously parsed sentences.

SENTENCE 20

It is Sir_Lancelot who knows Zoot!

```
# Sentences
S1 -> NP VP Eos | VP NP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP
```

['it', 'is', 'Sir_Lancelot', 'who', 'knows', 'Zoot', '!']
(START
  (S1
    (NP (PRP it))
    (VP
      (VerbT is)
      (NP
        (Proper Sir_Lancelot)
        (WP who)
        (VP (VBZ knows) (NP (Proper Zoot)))))
    (Eos !)))

Two new rules were generated for this sentence. The first rule was needed to parse
"Sir_Lancelot who knows Zoot". A rule was needed to define a NP as Proper (Sir_Lancelot)
WP (who) VP (a verb phrase). The second rule that was needed was for the VP "knows Zoot".
"knows" is a third person singular verb tagged as VBZ, a rule was needed for VBZ to be
followed by a NP.

either Arthur knows or Patsy does.

-The next sentence was parsed along with the intended sentence.

Neither Sir_Lancelot nor Guinevere will speak of it

```
# Sentences
S1 -> NP VP Eos | VP NP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO
```

RESULT

['either', 'Arthur', 'knows', 'or', 'Patsy', 'does', '.']
(START
  (S1
    (NP (CC either) (NP (Proper Arthur)))
    (VP (VBZ knows) (NP (CC or) (NP (Proper Patsy) (DO does))))
    (Eos .)))

-Parsed along with the intended sentence -
['neither', 'Sir_Lancelot', 'nor', 'Guinevere', 'will', 'speak', 'of', 'it', '.']
(START
  (S1
    (NP
      (CC neither)
      (NP (Proper Sir_Lancelot) (CC nor) (Proper Guinevere)))
    (VP (MD will) (VP (VBP speak) (PP (Prep of) (NP (PRP it)))))
    (Eos .)))

Two new rules were needed to parse the sentence. The first rule was for the NP "either
Arthur". "either" is a coordinating conjunction labeled CC. The rule we generated was CC NP.
This is in order to parse future sentences that start with CC and are followed by a rule we
already have for NP. The second rule we needed was Proper Do. This was in order to parse the
NP "Patsy does".

Arthur rode to Camelot and drank from his chalice.

```
# Sentences
S1 -> NP VP Eos | VP NP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP
```

['Arthur', 'rode', 'to', 'Camelot', 'and', 'drank', 'from', 'his', 'chalice', '.']
(START
  (S1
    (NP
      (Proper Arthur)
      (VP (VBD rode) (NP (TO to) (NP (NNP Camelot)))))
    (VP
      (CC and)
      (VP
        (VBD drank)
        (PP (Prep from) (NP (PRPS his) (NP (NN chalice))))))
    (Eos .)))

No new rules were needed for the initial NP. A new rule was added for the first VP. There
were no rules that stated VBD followed by a NP, so this was added to parse "rode to Camelot
and drank from his chalice". To parse "drank from his chalice" we added a new rule VBD PP,
"drank" is tagged as VBD and it is followed by "from" the beginning of a PP. Finally, a fourth
rule was needed for "his chalice" his is a possessive personal pronoun tagged as PRPS. To
parse any NP that start with PRPS we added the rule PRPS NP.

SENTENCE 24

they migrate precisely because they know they will grow.

CHANGES

```
# Sentences
S1 -> NP VP Eos | VP NP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP
```

RESULT

```
['they', 'migrate', 'precisely', 'because', 'they', 'know', 'they', 'will', 'grow', '.']
(START
  (S1
    (NP (PRP they))
    (VP
      (VBP migrate)
      (RB precisely)
      (IN because)
      (NP
        (PRP they)
        (VP
          (VBP know)
          (NP (PRP they) (VP (MD will) (VP (VBP grow)))))))
    (Eos .)))
(START
  (S1
    (NP
      (PRP they)
      (VP (VBP migrate) (RB precisely) (IN because) (NP (PRP they))))
```

```
    (VP (VBP know) (NP (PRP they) (VP (MD will) (VP (VBP grow)))))
    (Eos .)))
(START
  (S1
    (NP
      (PRP they)
      (VP
        (VBP migrate)
        (RB precisely)
        (IN because)
        (NP (PRP they) (VP (VBP know) (NP (PRP they))))))
    (VP (MD will) (VP (VBP grow)))
    (Eos .)))
```

One new rule was added for the beginning of the initial VP. "migrate precisely because they know they will grow". "migrate" is tagged as VBP, "precisely" is RB "because" is a subordinating conjunction tagged as IN and "they" starts off a new NP. Everything else in the sentence will be parsed with the existing rules. This sentence has the most parse trees at 3. There might be a better option for this sentence.

do not speak again!

CHANGES

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP
```

RESULT

['do', 'not', 'speak', 'again', '!']

```
(START
 (S1 (VP (DO do) (NOT not) (VP (VBP speak) (RB again))) (Eos !)))
```

Three rules were added to be able to successful parse this command. First, there is no NP in this sentence, therefore we had to state that a sentence could be comprised of only a VP and Eos. There were no rules for a VP that started with the tags DO NOT; therefore, we added a rule that a VP can be DO NOT VP. Finally, to parse "speak again" we added the VP rule VBP followed by RB.

Arthur, sixty inches, is a tiny king.

-The next sentence was parsed along with the intended sentence.
Arthur knows Patsy, the trusty servant.

CHANGES

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P
```

RESULT

['Arthur', ',', 'sixty', 'inches', ',', 'is', 'a', 'tiny', 'king', '.']
(START
 (S1
  (NP
   (Proper Arthur)

```
    (P ,)
    (NP (CD sixty) (NP (NNS inches) (P ,))))
  (VP (VerbT is) (NP (Det a) (NP (JJ tiny) (NP (NN king)))))
  (Eos .)))
```

The second sentence that was able to be parsed with the addition of the rules.

```
['Arthur', 'knows', 'Patsy', ',', 'the', 'trusty', 'servant', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP
      (VBZ knows)
      (NP
        (Proper Patsy)
        (P ,)
        (NP (Det the) (NP (JJ trusty) (NP (NN servant))))))
    (Eos .)))
```

Two additional rules were needed to parse this sentence. This is the first sentence that includes commas, which are Pauses and tagged as P. The first rule Proper P NP parses the beginning of the initial NP "Arthur, sixty inches,". To parse "inches," NNS P was added. These addition of these rules allowed the sentence "Arthur knows Patsy, the trusty servant" to be parsed.

Arthur suggested that the castle be carried.

CHANGES

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB | VB VBN

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
```

```
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P | IN NP VP
```

RESULT

['Arthur', 'suggested', 'that', 'the', 'castle', 'be', 'carried', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP
      (VBD suggested)
      (NP
        (IN that)
        (NP (Det the) (NP (NN castle)))
        (VP (VB be) (VBN carried))))
    (Eos .)))
(START
  (S1
    (NP
      (Proper Arthur)
      (VP
        (VBD suggested)
        (NP (Det that) (NP (Det the) (NP (NN castle))))))
    (VP (VB be) (VBN carried))
    (Eos .)))
(START
  (S1
    (NP
      (Proper Arthur)
      (VP
        (VBD suggested)
        (NP (WDT that) (NP (Det the) (NP (NN castle))))))
    (VP (VB be) (VBN carried))
    (Eos .)))

This also created a second parse tree for Sir_Lancelot might have spoken. This happened
because "have" is tagged as both a VBP and VB and with the inclusion of the VB VBN rule it
parses "have spoken".
(START
  (S1
    (NP (Proper Sir_Lancelot))
    (VP (MD might) (VP (VB have) (VBN spoken)))
    (Eos .)))

Two additional rules were needed to parse this sentence. The first rule was for the first NP nestled in the VP. In this case, "that" is a subordinating conjunction tagged as IN. It is followed by a NP "the castle" and a VP "be carried". A new rule was needed for the VP "be carried", "be" is in its base form VB and "carried" is a past participle VBN. The new rules parsed this sentence 3 times. It is because "that" is tagged three different ways: IN, Det, and WDT. Rules were already in place to parse the sentence with a Det NP and a WDT NP, explaining why the sentence was parsed 3 different times.

SENTENCE 29

the king drank to the castle that was his home.

CHANGES

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB | VB VBN

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P | IN NP VP | NN WDT VP
```

RESULT

```
['the', 'king', 'drank', 'to', 'the', 'castle', 'that', 'was', 'his', 'home', '.']
(START
  (S1
    (NP (Det the) (NP (NN king)))
    (VP
      (VBD drank)
      (NP
        (TO to)
        (NP
          (Det the)
          (NP
```

```
        (NN castle)
        (WDT that)
        (VP (VBD was) (NP (PRPS his) (NP (NN home))))))))
    (Eos .)))
```

Only one new rule was needed to fully parse this sentence. The initial NP is parsed with the
existing grammar rules. The beginning of the VP is also parsed with the existing grammar rule
VBD NP. The NP "castle that was his home" requires the addition of a new rule to be parsed.
"castle" is a NN, in this case "that" is functioning as a WDT and "was" is the start of a new
VP. The new rule is NN WDT VP. The remainder of the sentence is parsed with the existing
rules.

SENTENCE 30

when the king drinks, Patsy drinks.

CHANGES

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB | VB VBN | VerbT P NP | VerbT

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP | NNS P | IN NP VP | NN WDT VP
```

RESULT

['when', 'the', 'king', 'drinks', ',', 'Patsy', 'drinks', '.']
(START
  (S1
    (NP (WRB when) (NP (Det the) (NP (NN king))))
    (VP (VerbT drinks) (P ,) (NP (Proper Patsy) (VP (VerbT drinks))))
    (Eos .)))

Two new rules were needed to parse this sentence. No new rules were needed for the initial
NP. The first rule added is for the VP "drinks, Patsy drinks". There are no rules for "," or

pauses in the VPs. The rule is VerbT P NP this accounts for the third personal singular present transitive verb "drinks" (VBZ) the "," (P) and the NP that follows. The final rule was for "drinks" with nothing but the Eos following it. A simple VerbT rule was added to the VP.

unfortunately, Sir_Lancelot speaks again.

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#  Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB | VB VBN | VerbT P NP | VerbT | RB P | VBZ RB

#  Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P | IN NP VP | NN WDT VP
```

['unfortunately', ',', 'Sir_Lancelot', 'speaks', 'again', '.']
(START
 (S1
  (VP (RB unfortunately) (P ,))
  (NP (Proper Sir_Lancelot) (VP (VBZ speaks) (RB again)))
  (Eos .)))

Two new rules were needed to parse this sentence. The initial VP needed a new rule to account for an adverb followed by a pause. Therefore, the rule RB P was added. The NP did not need any additional rules. However, the VP nestled inside of it did. "speaks again" is comprised of a third person singular verb and an adverb so the rule VBZ RB was included.

Issues:

The sentence "he knows what they are covering with that story" needs further attention to appropriately parse. All attempts to parse this sentence resulted in multiple parse trees. This could be due to the fact that multiple words in the sentence have numerous tags.

Part 2

SENTENCE THAT CANNOT BE PARSED BY OUR CURRENT RULES
Frequently, Guinevere goes to the castle to speak with the king.
CURRENT GRAMMAR RULES
S1 -> NP VP Eos | VP NP Eos | VP Eos # Verb phrases VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN NP | DO NOT VP | VBP RB | VB VBN | VerbT P NP | VerbT | RB P | VBZ RB # Noun phrases NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS | CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P | IN NP VP | NN WDT VP
RESULT
['frequently', ',', 'Guinevere', 'goes', 'to', 'the', 'castle', 'to', 'speak', 'with', 'the', 'king', '.'] ['Arthur', 'will', 'covered', 'from', 'lucky', 'his', 'coconut', '.'] This sentence is unable to be parsed by our current grammar rules. The start of the sentence is a RB (adverb) followed by P (a comma) and then a NP (noun phrase). We do have a rule for VP that starts with an RB (adverb) and is followed by a P (pause), which should parse this part of the sentence and then according to our sentence rules automatically go to the NP. The NP "Guinevere goes …" would be Proper VP. We do have this rule included in our grammar rules, so this part of the sentence would be parsed. "goes to the castle" is the next phrase that needs to be parsed. "goes" is a VBZ followed by "to the castle" TO NP. We need to see if we have a rule for VBZ TO NP or VBZ NP and then a rule in NP that is TO NP. Which we do have. The rules that would parse this part of the sentence VBZ NP and the in NP we have TO NP. These two rules would successfully parse "goes to the castle". This though is as far as our current

grammar rules will take us in parsing this sentence. We need a rule that will parse "castle to speak with the king", which we do not have. We do not have a rule that will connect "castle" and "to speak". We have a rule that will connect "castle" and TO NP, but we are need the following rule NN TO VP and then the rule VB PP to parse the sentence correctly. Another rule that could be added that would allow the sentence to be parsed is the rule NN VP and then the following rule in VP: TO VB PP.

Arthur will covered from lucky his coconut.

```
S1 -> NP VP Eos | VP NP Eos | VP Eos

#   Verb phrases
VP -> VerbT NP | VBD VBN NP | VBP PP | MD VP | VBP VBN | VBD VBN VBG
PP | VBP VBN VBG NP | VBP RB RB | VBP RB PP | VBZ TO VB NP | VerbT
NOT JJ | VBP | VBP NP | VBZ NP | VBD NP | CC VP | VBD PP | VBP RB IN
NP | DO NOT VP | VBP RB | VB VBN | VerbT P NP | VerbT | RB P | VBZ RB

#   Noun phrases
NP -> Proper | Det NP | NN | NN PP | NNP | JJ NP | TO NP | JJS NNS |
CC NP | NNS | Proper PP | NNPS | Proper CC Proper | PRP | VBG NP | DO
NP | WRB NP | WDT NP | NN NP | WP NP | PRP VP | Proper VP | Proper WP
VP | CC NP | Proper DO | PRPS NP | Proper P NP| NNS P | IN NP VP | NN WDT VP
```

```
 ['Arthur', 'will', 'covered', 'from', 'lucky', 'his', 'coconut', '.']
(START
  (S1
    (NP (Proper Arthur))
    (VP
      (MD will)
      (VP
        (VBD covered)
        (PP
          (Prep from)
          (NP (JJ lucky) (NP (PRPS his) (NP (NN coconut)))))))
    (Eos .)))
```

Even though the sentence does not make any sense, it is parsed because it is made of rules we have already specified. First, the initial NP "Arthur" is parsed with the rule Proper, the parser automatically goes to the next part of our sentence VP. The first VP
will covered" is parsed with our rule: MD VP. Then the next phrase "covered from" is parsed with the rule VBD PP. "will covered" does not make sense in English, however because we included the rule MD VP, will can be followed by any of our other grammar rules. It does not matter if this makes sense grammatically or not. The next phrase "covered from" is parsed with the rule VBD PP. "from lucky" is parsed with our PP rule: Prep NP. "lucky his" is parsed with our JJ NP. "his coconut" is parsed with our PRPS NP and "coconut" is parsed with our NN rule. We were able to parse a nonsensical sentence, because our grammar rules were able to connect to other grammar rules, regardless if they made sense or not due to us generalizing and adding NP and VP to the end of certain rules. While this does help us, it lends itself to overgeneralization. This is an area where we might want to go back and discuss making stricter rules, that do not allow for this overgeneralization.