

## Solution for HW4

Q1: Translate the grammar below into Chomsky Normal Form. (It would probably be quicker to cut and paste this and then type your answers.)

| Grammar                                     | Chomsky Normal Form  |
|---|--|
| $S \rightarrow NP VP$                       | $S \rightarrow NP VP$  |
| $NP \rightarrow DET Nom$                    | $NP \rightarrow DET Nom$   |
| $NP \rightarrow DET ADJS Nom$               | $NP \rightarrow X1 Nom$<br>$X1 \rightarrow DET ADJS$               |
| $ADJS \rightarrow ADJ ADJS$                 | $ADJS \rightarrow ADJ ADJS$  |
| $ADJS \rightarrow ADJ$                      | $ADJS \rightarrow red$   |
| $NP \rightarrow DET Nom$                    | $NP \rightarrow DET Nom$   |
| $NP \rightarrow PN$                         | $NP \rightarrow Juan$  |
| $NP \rightarrow NP PP$                      | $NP \rightarrow NP PP$   |
| $Nom \rightarrow N$                         | $Nom \rightarrow table$  |
| $VP \rightarrow TransV NP$                  | $VP \rightarrow TransV NP$   |
| $VP \rightarrow TransV$                     | $VP \rightarrow ate$   |
| $VP \rightarrow TransV NP PP$               | $VP \rightarrow X2 PP$<br>$X2 \rightarrow TransV NP$               |
| $VP \rightarrow IntransV PP$                | $VP \rightarrow IntransV PP$                                       |
| $VP \rightarrow PropositionalVerb SubDet S$ | $VP \rightarrow X3 S$<br>$X3 \rightarrow PropositionalVerb SubDet$ |
| $VP \rightarrow PropositionalVerb S$        | $VP \rightarrow PropositionalVerb S$                               |
| $PP \rightarrow PREP NP$                    | $PP \rightarrow PREP NP$   |

Q2: Confirm the probabilities on slide 15 of chapter14part1.ppt. That is, show how they are derived.

| Original Grammar                   |     | Chomsky Normal Form                |       |   |
|------------------------------------|-----|------------------------------------|-------|---|
| $S \rightarrow NP VP$              | 0.8 | $S \rightarrow NP VP$              | 0.8   | same as original  |
| $S \rightarrow Aux NP VP$          | 0.1 | $S \rightarrow X1 VP$              | 0.1   | same as original ( $S \rightarrow Aux NP VP$ )  |
|                                    |     | $X1 \rightarrow Aux NP$            | 1.0   | it is the only way to take $X1$   |
| $S \rightarrow VP$                 | 0.1 | $S \rightarrow book$               | 0.01  | $p(S \rightarrow VP) * p(VP \rightarrow Verb)$<br>$* p(Verb \rightarrow book) = 0.1 * 0.2 * 0.5$    |
|                                    |     | $S \rightarrow include$            | 0.004 | $p(S \rightarrow VP) * p(VP \rightarrow Verb)$<br>$* p(Verb \rightarrow include) = 0.1 * 0.2 * 0.2$ |
|                                    |     | $S \rightarrow prefer$             | 0.006 | $p(S \rightarrow VP) * p(VP \rightarrow Verb)$<br>$* p(Verb \rightarrow prefer) = 0.1 * 0.2 * 0.3$  |
|                                    |     | $S \rightarrow Verb NP$            | 0.05  | $p(S \rightarrow VP) * p(VP \rightarrow Verb NP)$<br>$= 0.1 * 0.5$                                  |
|                                    |     | $S \rightarrow VP PP$              | 0.03  | $p(S \rightarrow VP) * p(VP \rightarrow VP PP) = 0.1 * 0.3$   |
| $NP \rightarrow Pronoun$           | 0.2 | $NP \rightarrow I$                 | 0.1   | $p(NP \rightarrow Pronoun) * p(Pronoun \rightarrow I)$<br>$= 0.2 * 0.5$                             |
|                                    |     | $NP \rightarrow he$                | 0.02  | $p(NP \rightarrow Pronoun) * p(Pronoun \rightarrow he)$<br>$= 0.2 * 0.1$                            |
|                                    |     | $NP \rightarrow she$               | 0.02  | $p(NP \rightarrow Pronoun)$<br>$* p(Pronoun \rightarrow she) = 0.2 * 0.1$                           |
|                                    |     | $NP \rightarrow me$                | 0.06  | $p(NP \rightarrow Pronoun)$<br>$* p(Pronoun \rightarrow me) = 0.2 * 0.3$                            |
| $NP \rightarrow Proper-Noun$       | 0.2 | $NP \rightarrow Houston$           | 0.16  | $p(NP \rightarrow Proper-Noun)$<br>$* p(Proper-Noun \rightarrow Houston) = 0.2 * 0.8$               |
|                                    |     | $NP \rightarrow HWA$               | 0.04  | $p(NP \rightarrow Proper-Noun) *$<br>$p(Proper-Noun \rightarrow HWA) = 0.2 * 0.2$                   |
| $NP \rightarrow Det Nominal$       | 0.6 | $NP \rightarrow Det Nominal$       | 0.6   | same as original  |
| $Nominal \rightarrow Noun$         | 0.3 | $Noun \rightarrow book$            | 0.03  | $p(Nominal \rightarrow Noun) * p(Noun \rightarrow book)$<br>$= 0.3 * 0.1$                           |
|                                    |     | $Noun \rightarrow flight$          | 0.15  | $p(Nominal \rightarrow Noun) * p(Noun \rightarrow flight)$<br>$= 0.3 * 0.5$                         |
|                                    |     | $Noun \rightarrow meal$            | 0.06  | $p(Nominal \rightarrow Noun) * p(Noun \rightarrow meal)$<br>$= 0.3 * 0.2$                           |
|                                    |     | $Noun \rightarrow money$           | 0.06  | $p(Nominal \rightarrow Noun)$<br>$* p(Noun \rightarrow money) = 0.3 * 0.2$                          |
| $Nominal \rightarrow Nominal Noun$ | 0.2 | $Nominal \rightarrow Nominal Noun$ | 0.2   | same as original  |
| $Nominal \rightarrow Nominal PP$   | 0.5 | $Nominal \rightarrow Nominal PP$   | 0.5   | same as original  |
| $VP \rightarrow Verb$              | 0.2 | $VP \rightarrow book$              | 0.1   | $p(VP \rightarrow Verb) * (Verb \rightarrow book)$<br>$= 0.2 * 0.5$                                 |
|                                    |     | $VP \rightarrow include$           | 0.04  | $p(VP \rightarrow Verb) * (Verb \rightarrow include)$<br>$= 0.2 * 0.2$                              |
|                                    |     | $VP \rightarrow prefer$            | 0.06  | $p(VP \rightarrow Verb) * (Verb \rightarrow prefer)$<br>$= 0.2 * 0.3$                               |
| $VP \rightarrow Verb NP$           | 0.5 | $VP \rightarrow Verb NP$           | 0.5   | same as original  |
| $VP \rightarrow VP PP$             | 0.3 | $VP \rightarrow VP PP$             | 0.3   | same as original  |
| $PP \rightarrow Prep NP$           | 1.0 | $PP \rightarrow Prep NP$           | 1.0   | same as original  |

Q4: Complete the table in Figure 14.4 of the text.

|            |   |           |            |   |
|------------|---|-----------|------------|---|
| Det: 0.4 ← | NP: $0.3 \cdot 0.4 \cdot 0.2$<br>= 0.0024 | None      | None       | S:<br>$0.8 \cdot 0.0024 \cdot$<br>0.000012<br>= 0.00000002304 |
| [0,1]      | [0,2]                                     | [0,3]     | [0,4]      | [0,5]   |
|            | N: 0.02                                   | None      | None       | None  |
|            | [1,2]                                     | [1,3]     | [1,4]      | [1,5]   |
|            |   | V: 0.05 ← | None       | VP:<br>$0.2 \cdot 0.05 \cdot 0.0012$<br>= 0.000012            |
|            |   | [2,3]     | [2,4]      | [2,5]   |
|            |   |           | Det: 0.4 ← | NP:<br>$0.3 \cdot 0.4 \cdot 0.01$<br>= 0.0012                 |
|            |   |           | [3,4]      | [3,5]   |
|            |   |           |            | N: 0.01   |
|            |   |           |            | [4,5]   |