Master in Artificial Intelligence

Introduction to Human Language Technologies
9. Syntactic parsing: parsers

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Facultat d'Informàtica de Barcelona

FIB

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

$NP \rightarrow cat|fish|knife$

$VP \rightarrow eats$

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

$NP \rightarrow cat|fish|knife$

$VP \rightarrow eats$

(C) Convert non-binary rules

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

$NP \rightarrow cat|fish|knife$

$VP \rightarrow eats$

(C) Convert non-binary rules

Exercise 1

Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

(A) Convert hybrid rules

$PP \rightarrow A\ NP$

$A \rightarrow with$

(B) Convert unit productions

$NP \rightarrow cat|fish|knife$

$VP \rightarrow eats$

(C) Convert non-binary rules

$VP \rightarrow vtB$

$B \rightarrow NP\ PP$

Exercise 1

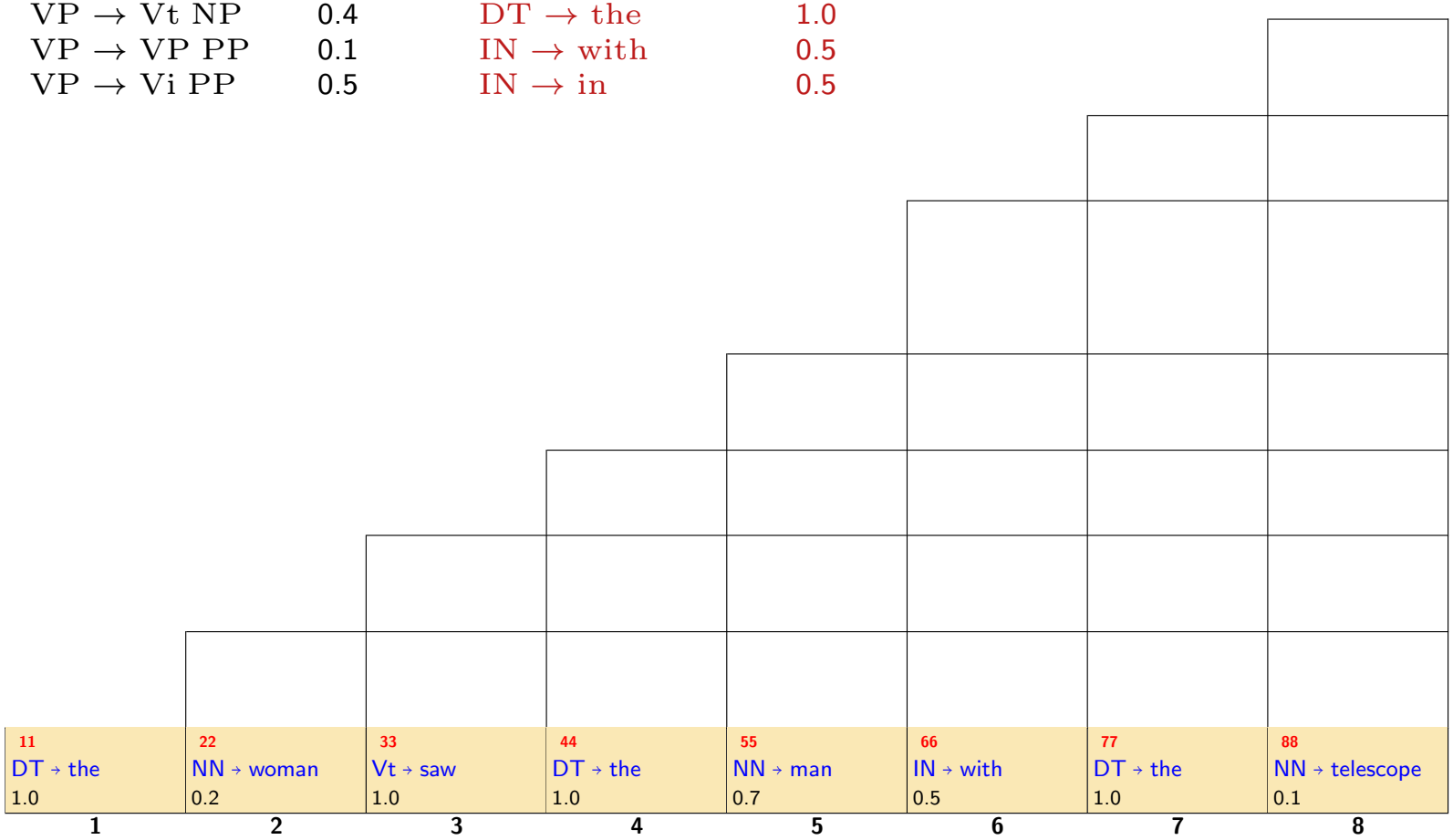
Convert the following CFG to CNF

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow n$
4. $VP \rightarrow vt\ NP\ PP$
5. $VP \rightarrow vi$
6. $PP \rightarrow with\ NP$
7. $det \rightarrow the|a$
8. $n \rightarrow cat|fish|knife$
9. $vt \rightarrow eats$
10. $vi \rightarrow eats$

1. $S \rightarrow NP\ VP$
2. $NP \rightarrow det\ n$
3. $NP \rightarrow cat|fish|knife$
4. $VP \rightarrow vt\ B$
5. $B \rightarrow NP\ PP$
6. $VP \rightarrow eats$
7. $PP \rightarrow A\ NP$
8. $A \rightarrow with$
9. $det \rightarrow the|a$
10. $n \rightarrow cat|fish|knife$
11. $vt \rightarrow eats$

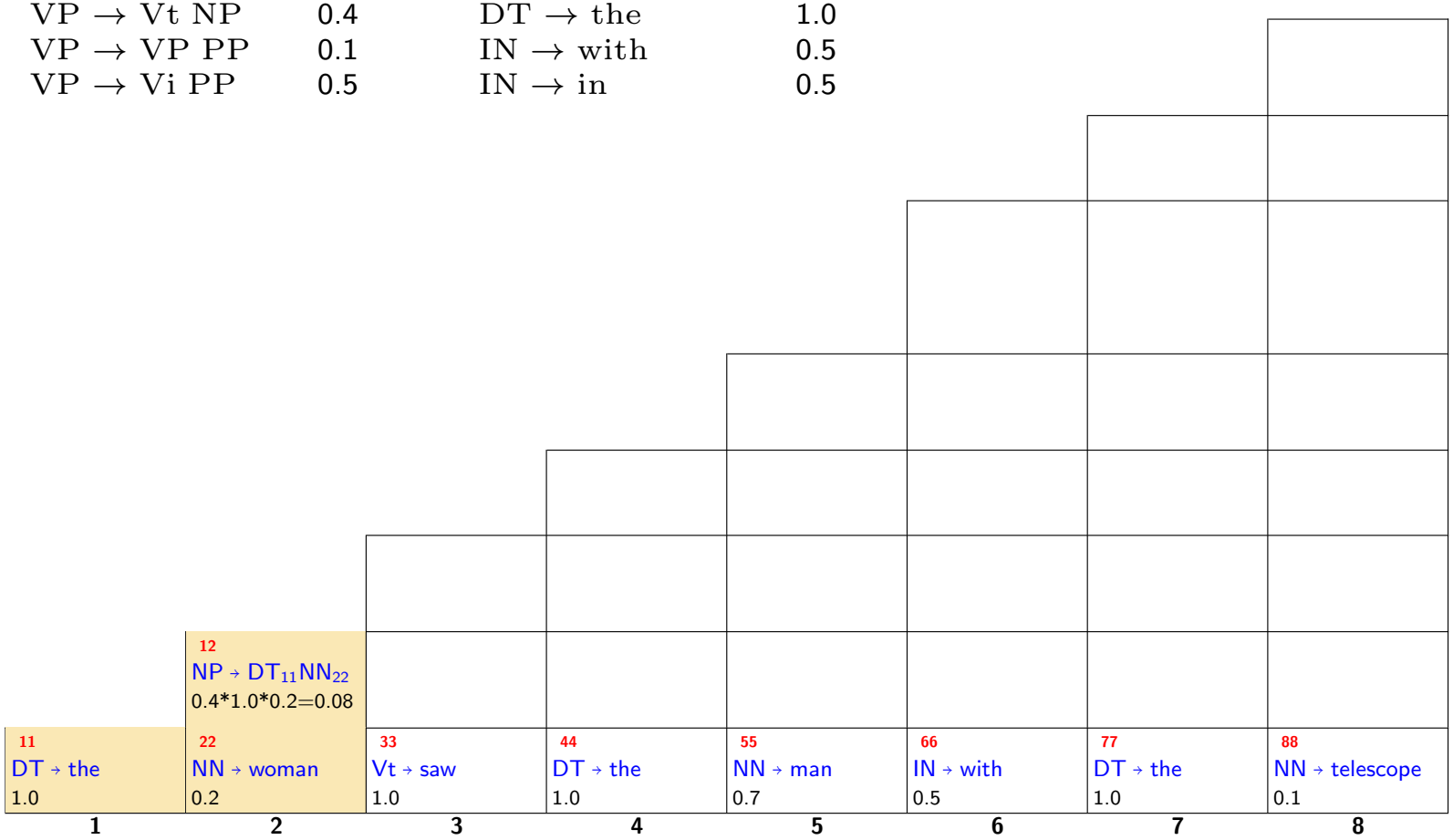
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



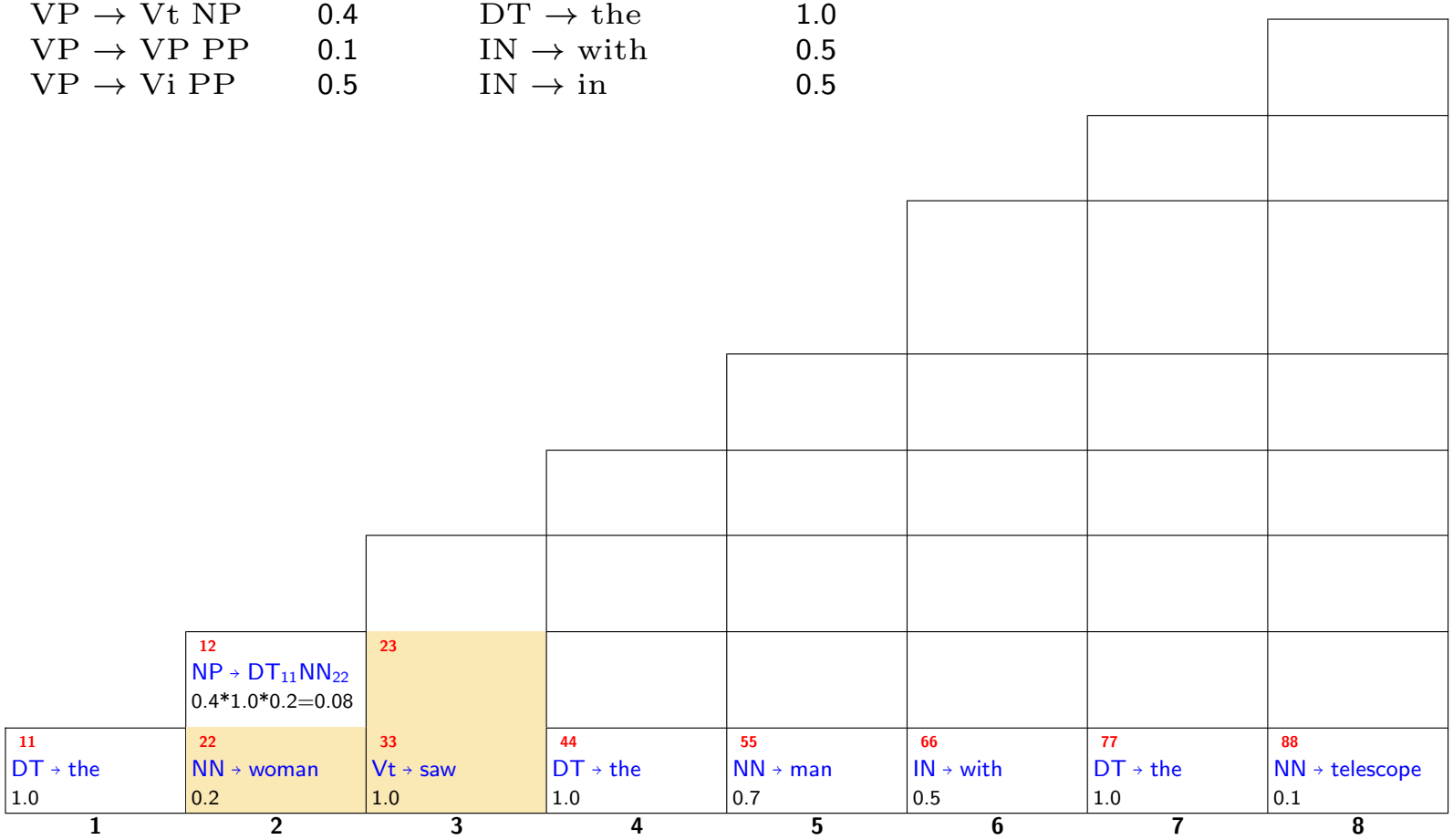
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



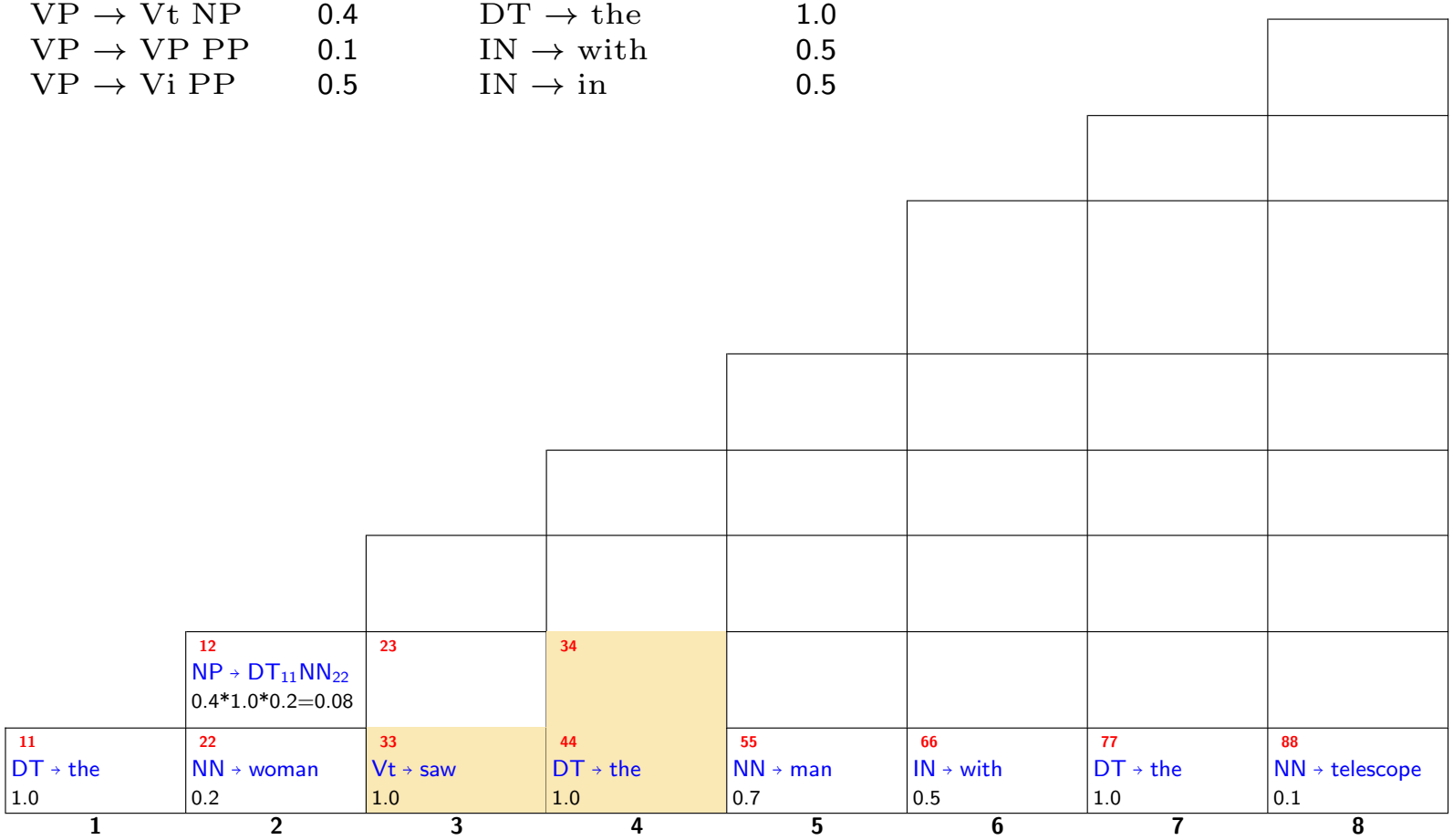
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



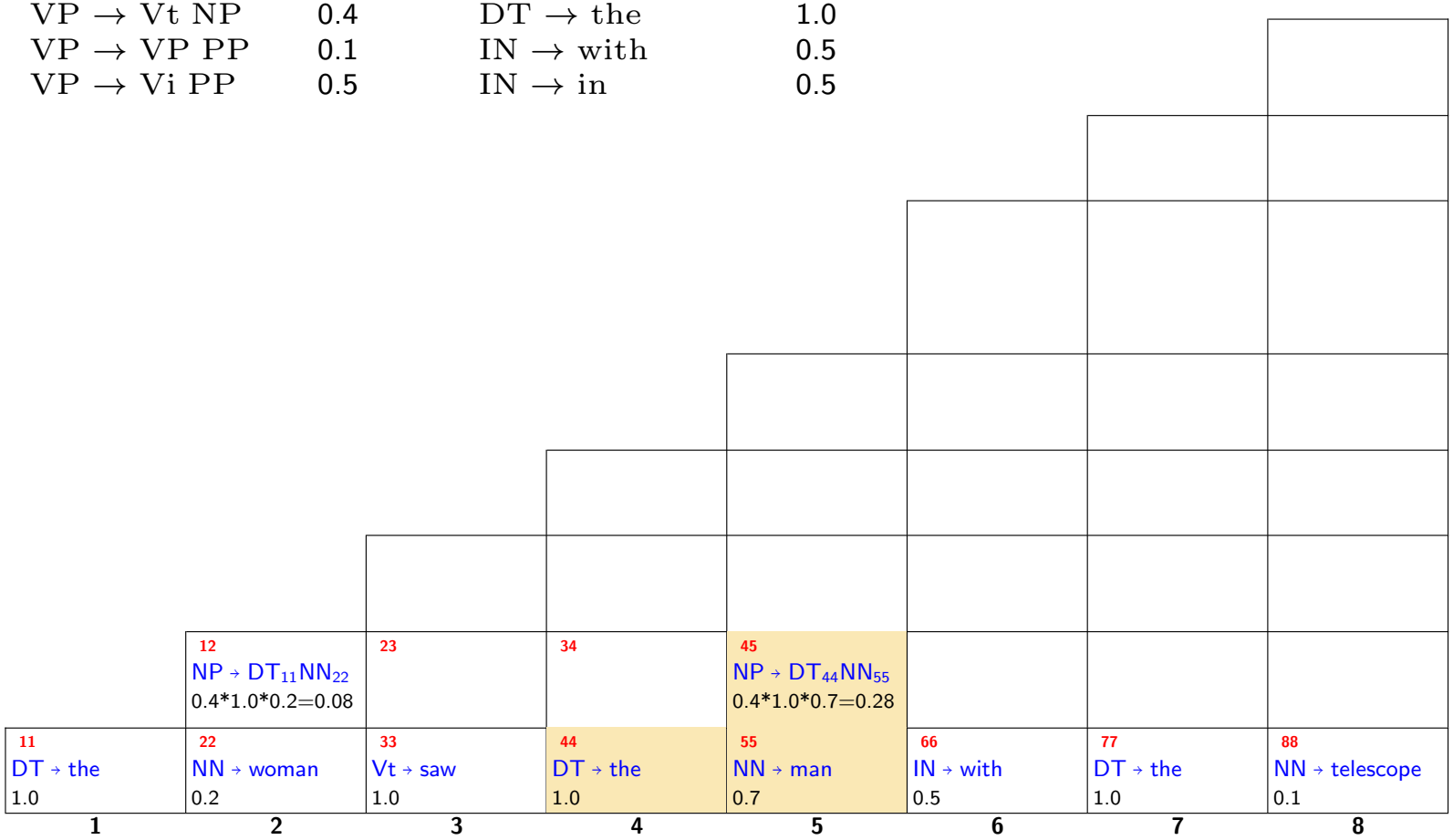
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



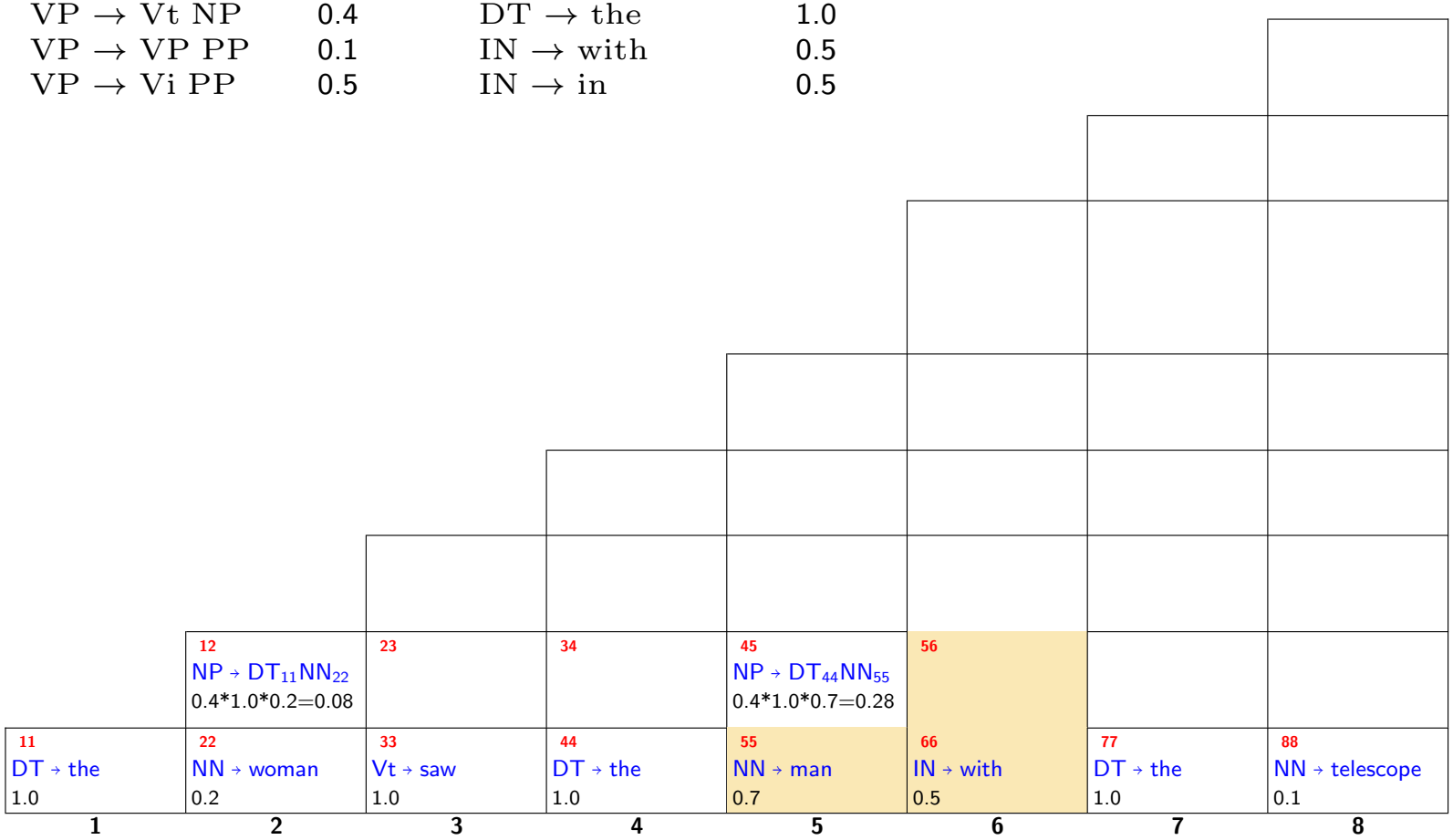
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



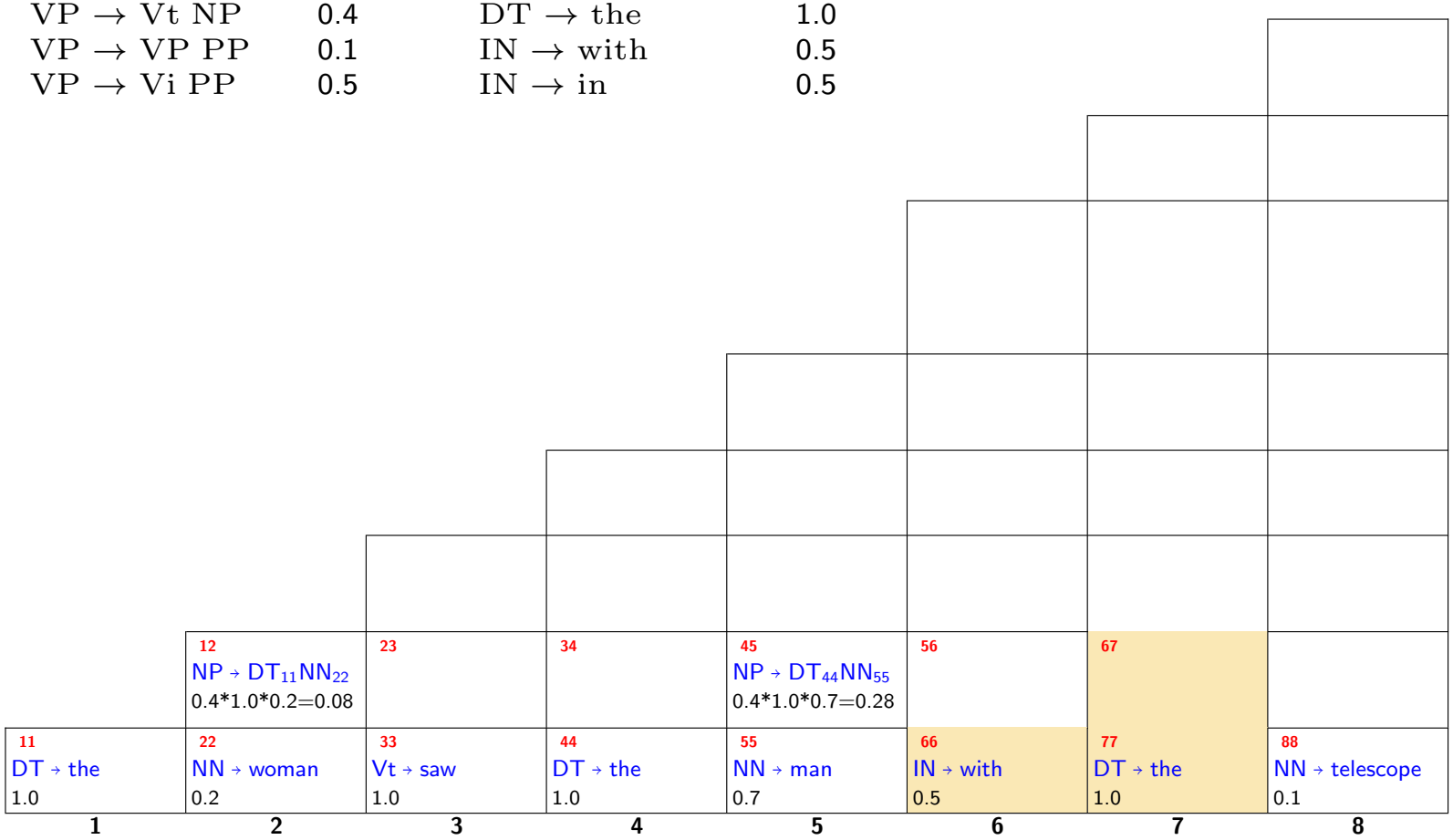
Exercise 2

$S \rightarrow NP\ VP$	0.5	$Vi \rightarrow sleeps$	1.0
$S \rightarrow NP\ Vi$	0.5	$Vt \rightarrow saw$	1.0
$NP \rightarrow DT\ NN$	0.4	$NN \rightarrow man$	0.7
$NP \rightarrow NP\ PP$	0.6	$NN \rightarrow woman$	0.2
$PP \rightarrow IN\ NP$	1.0	$NN \rightarrow telescope$	0.1
$VP \rightarrow Vt\ NP$	0.4	$DT \rightarrow the$	1.0
$VP \rightarrow VP\ PP$	0.1	$IN \rightarrow with$	0.5
$VP \rightarrow Vi\ PP$	0.5	$IN \rightarrow in$	0.5



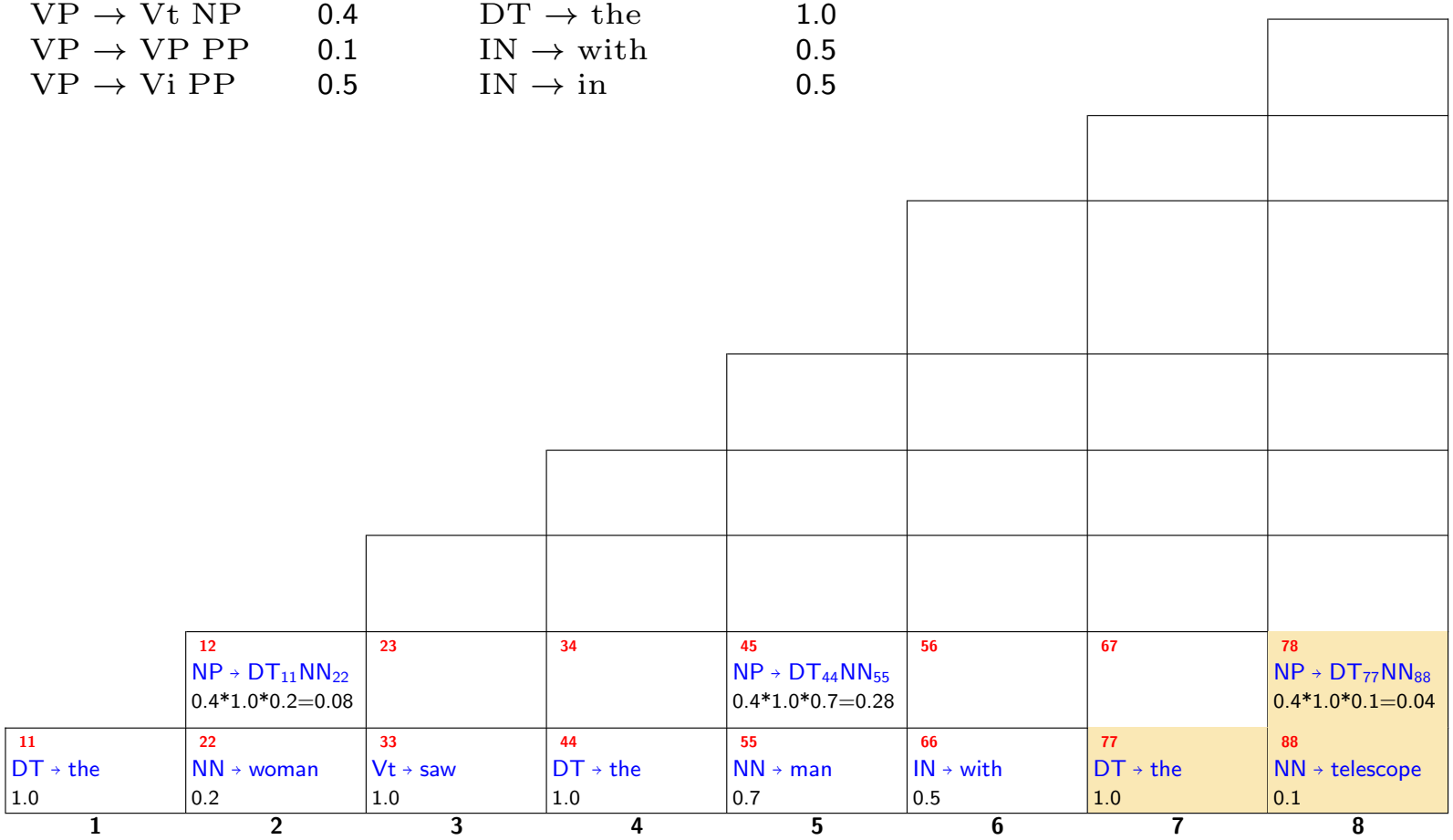
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



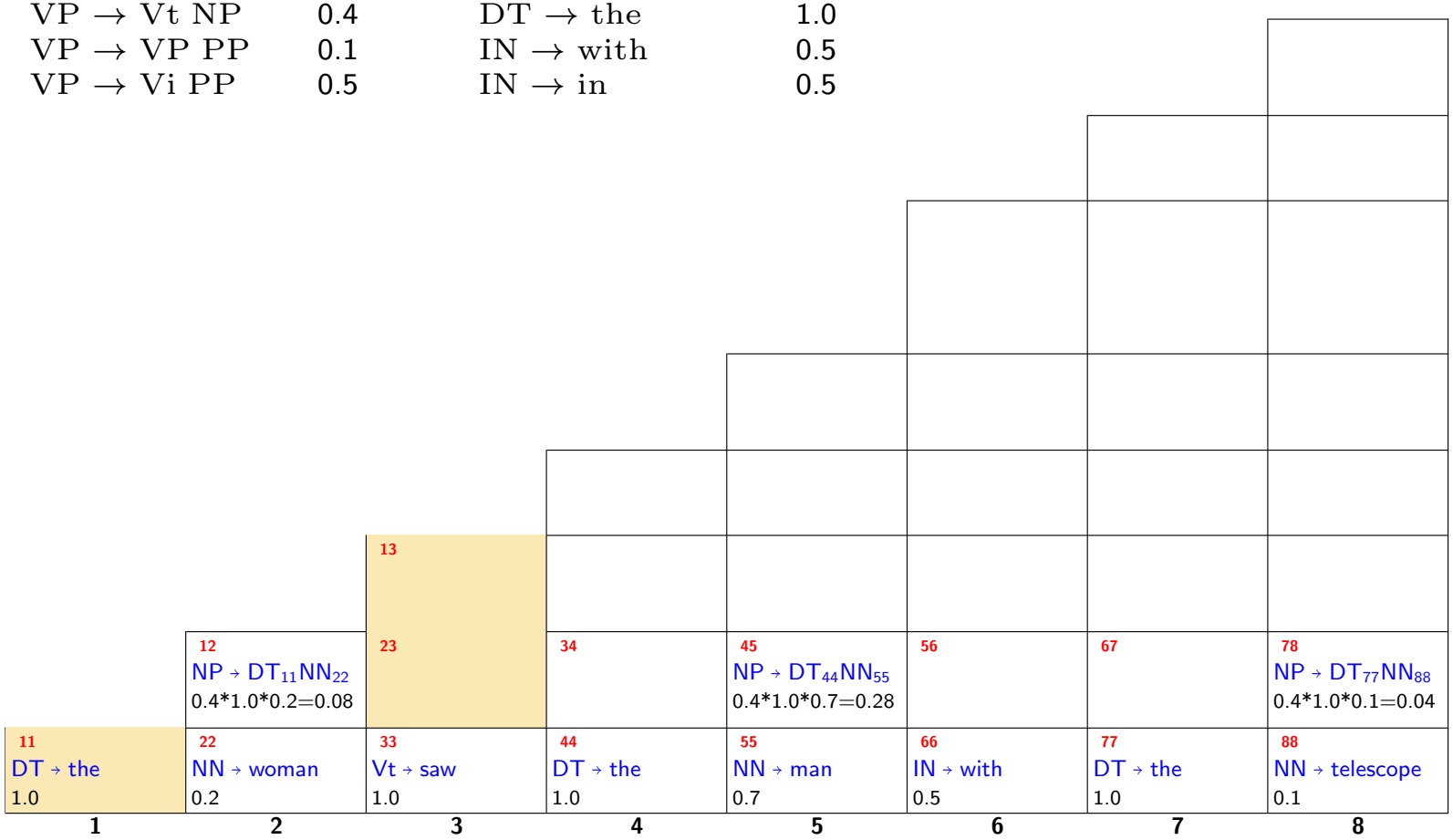
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



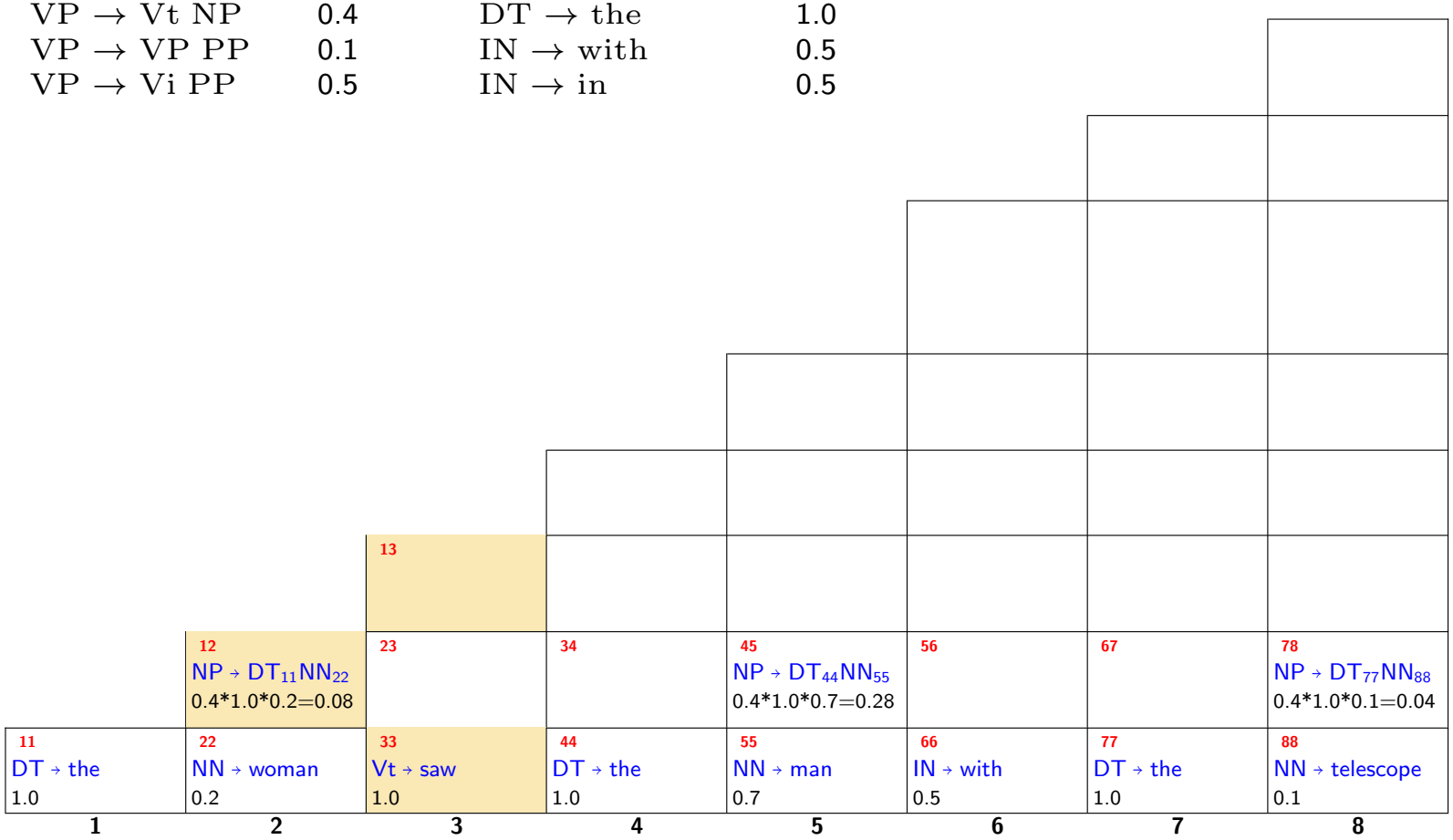
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



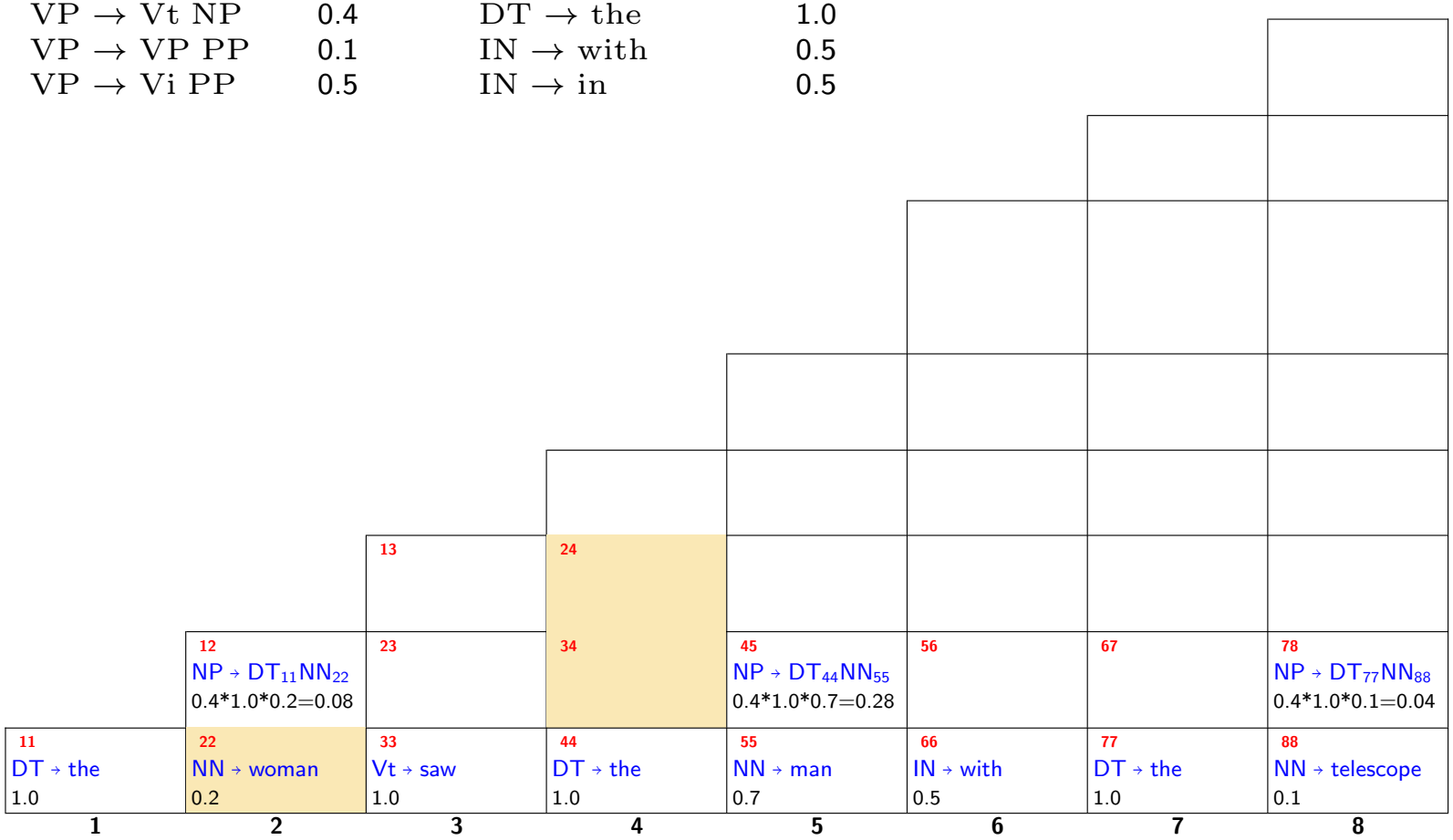
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



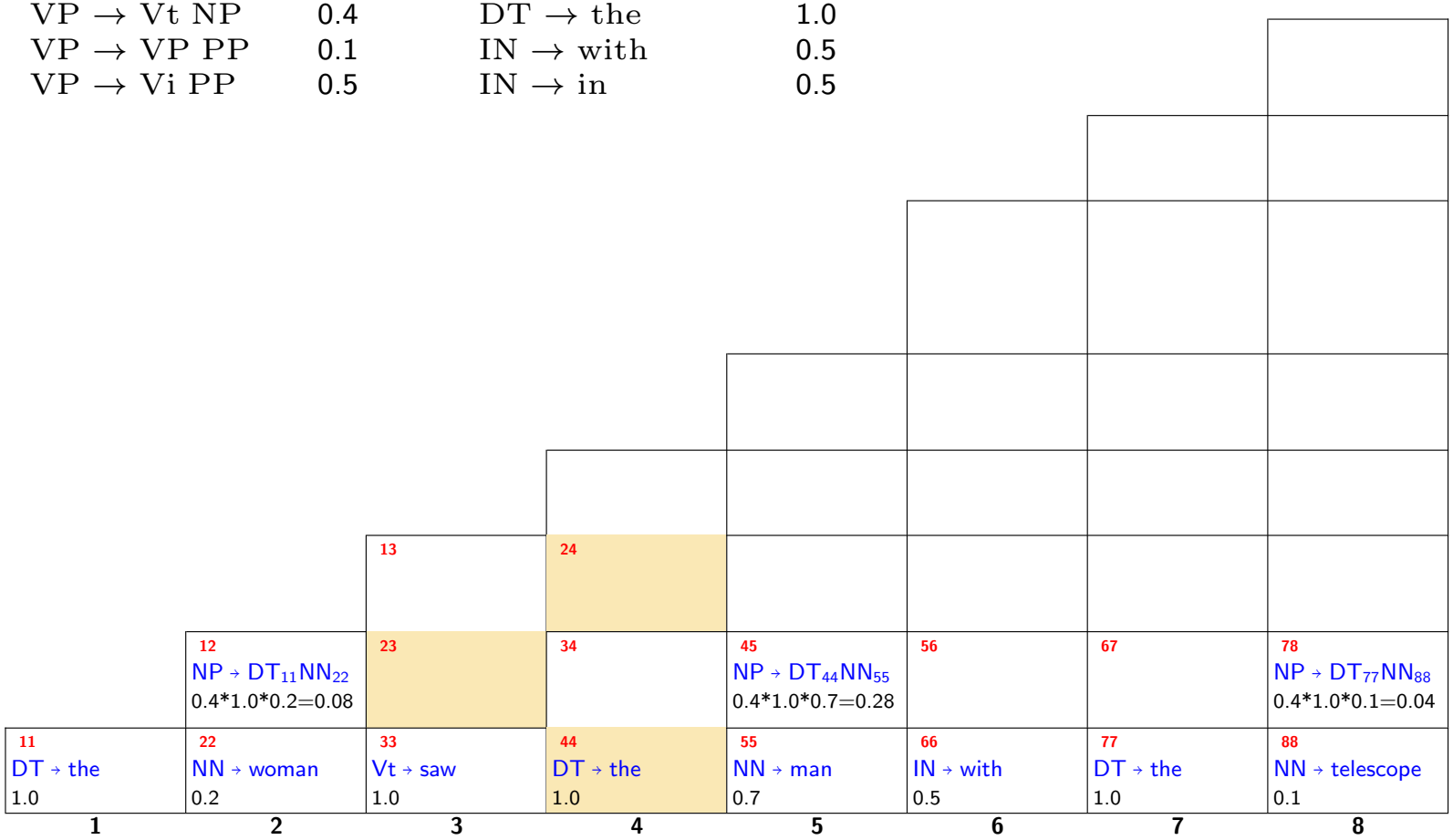
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



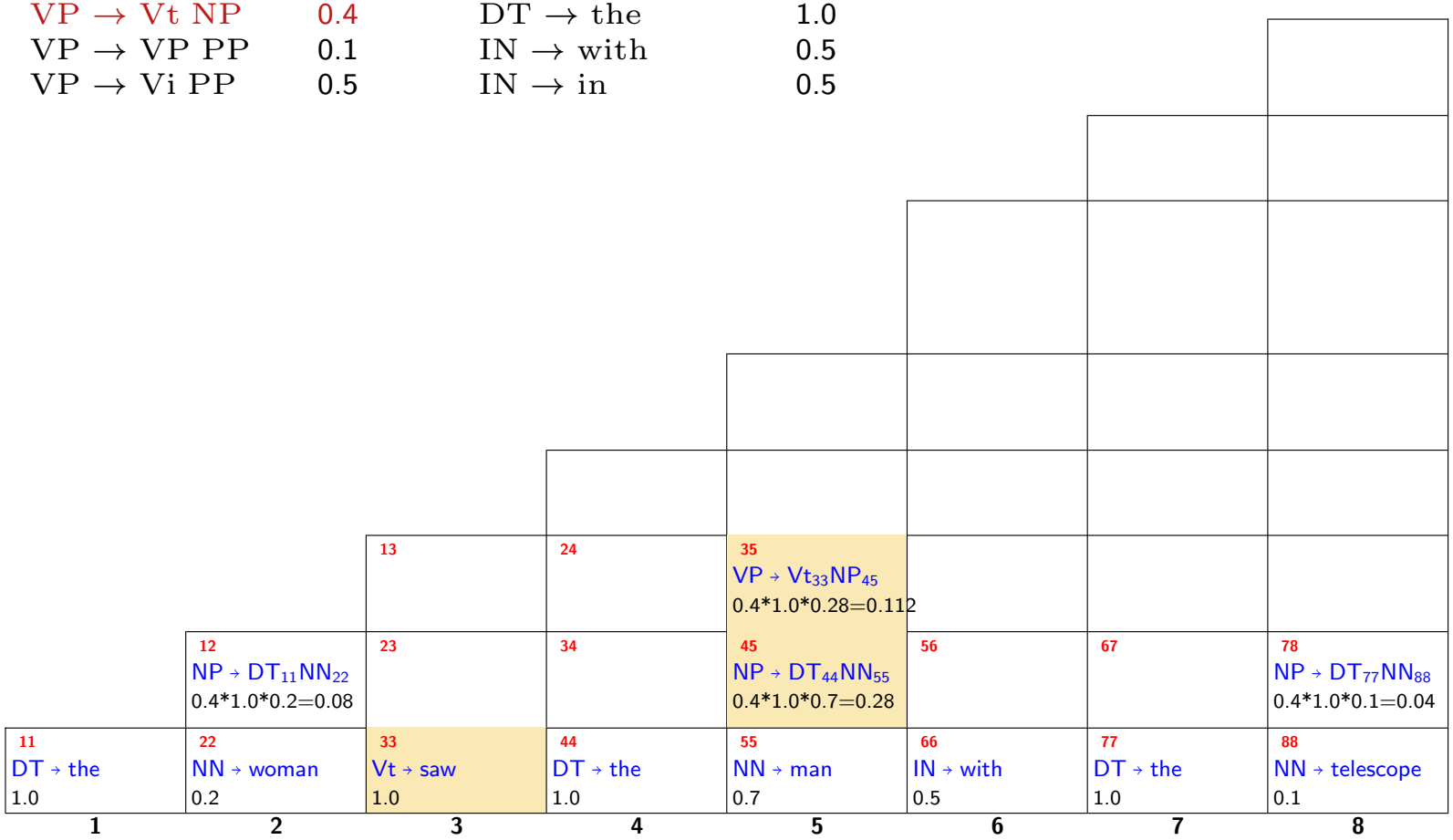
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



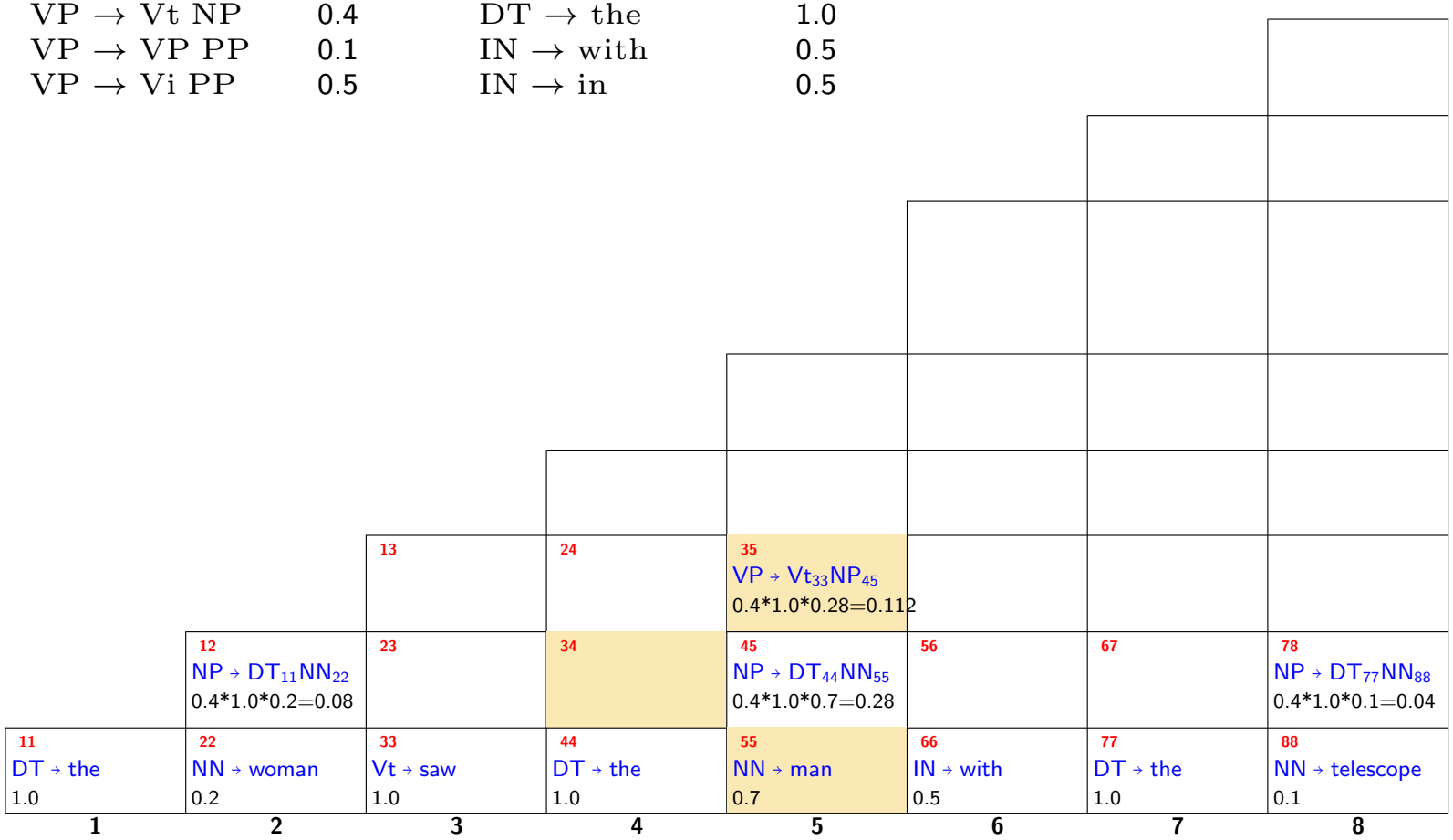
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



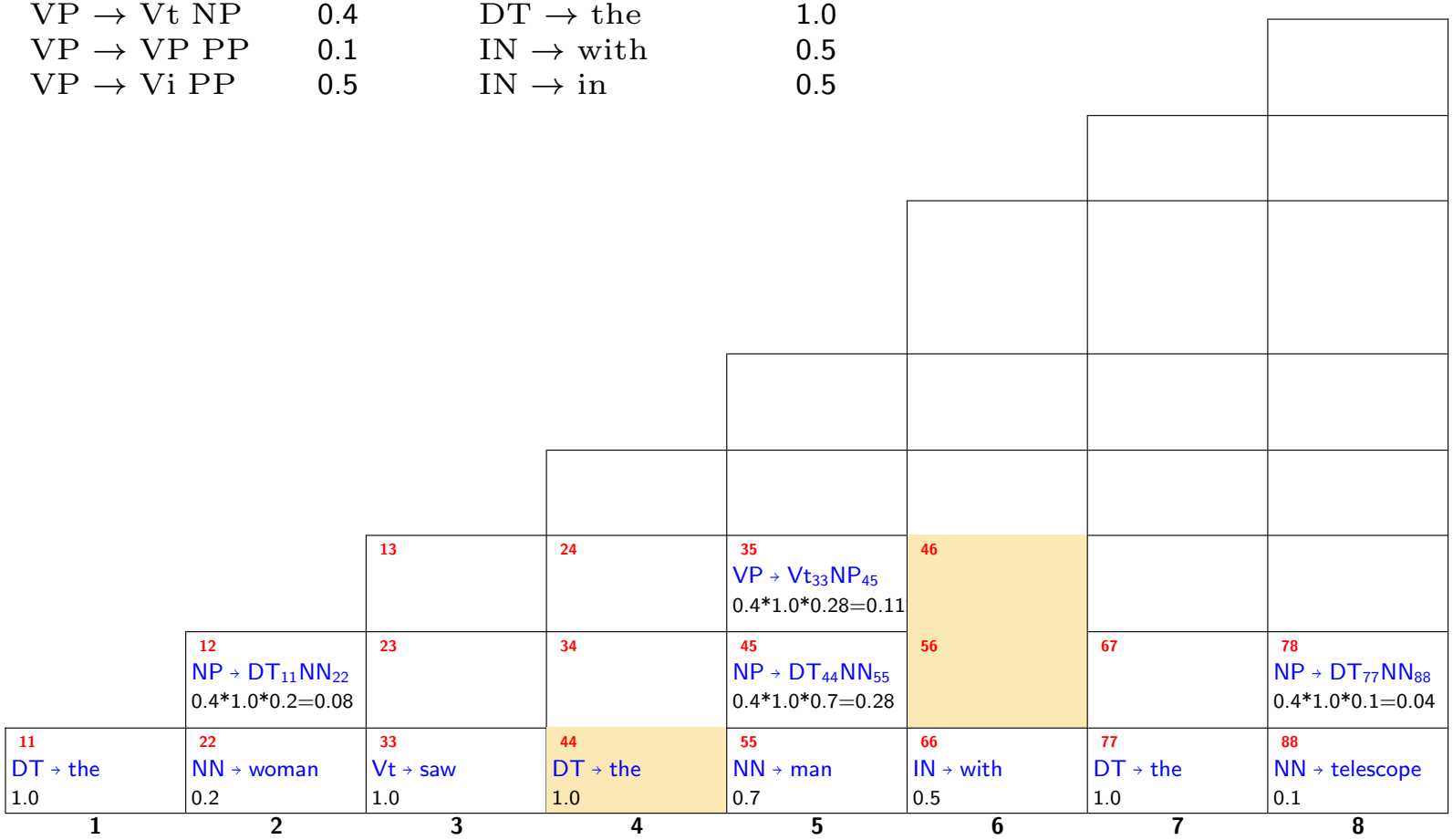
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



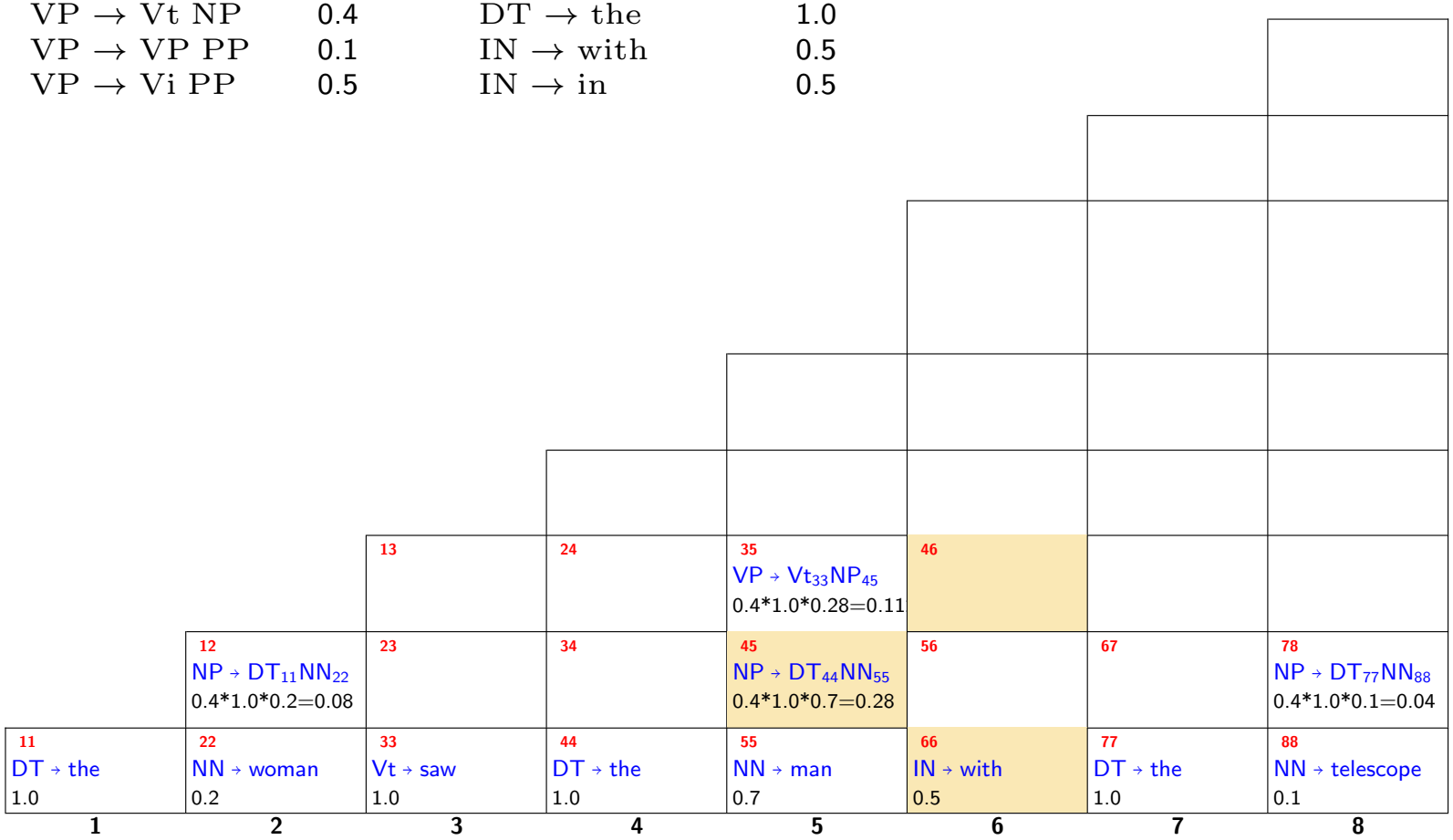
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



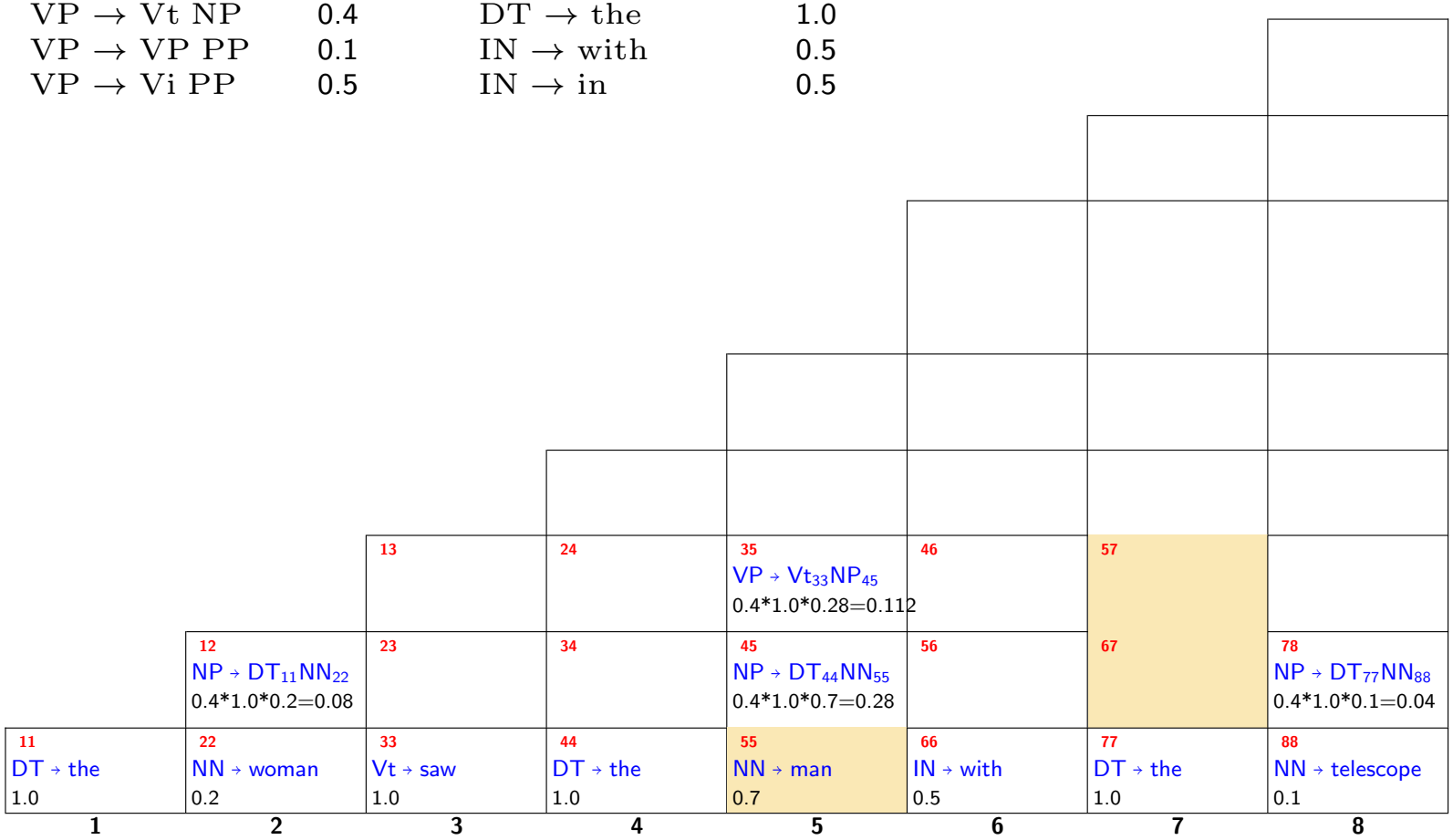
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



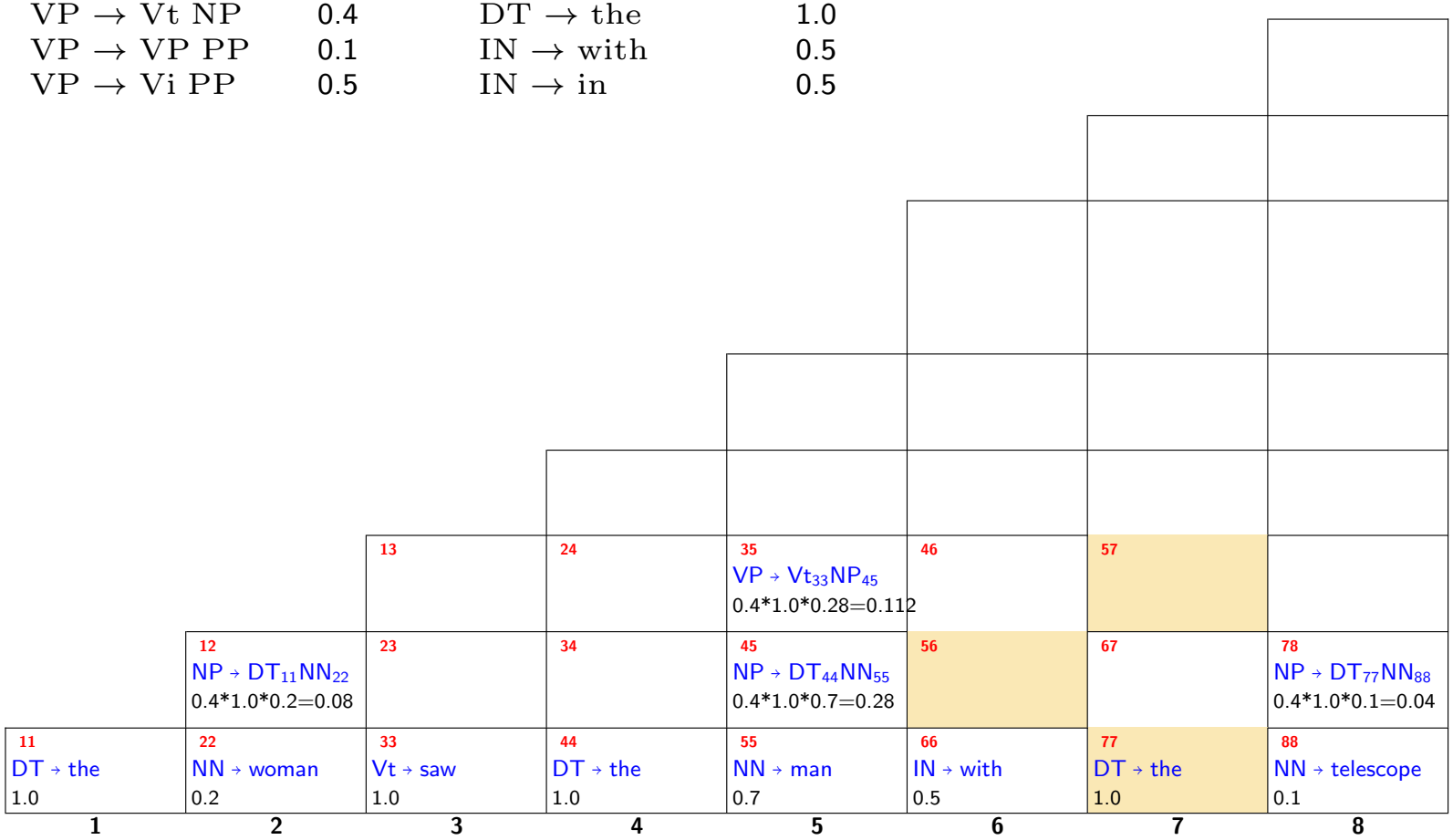
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



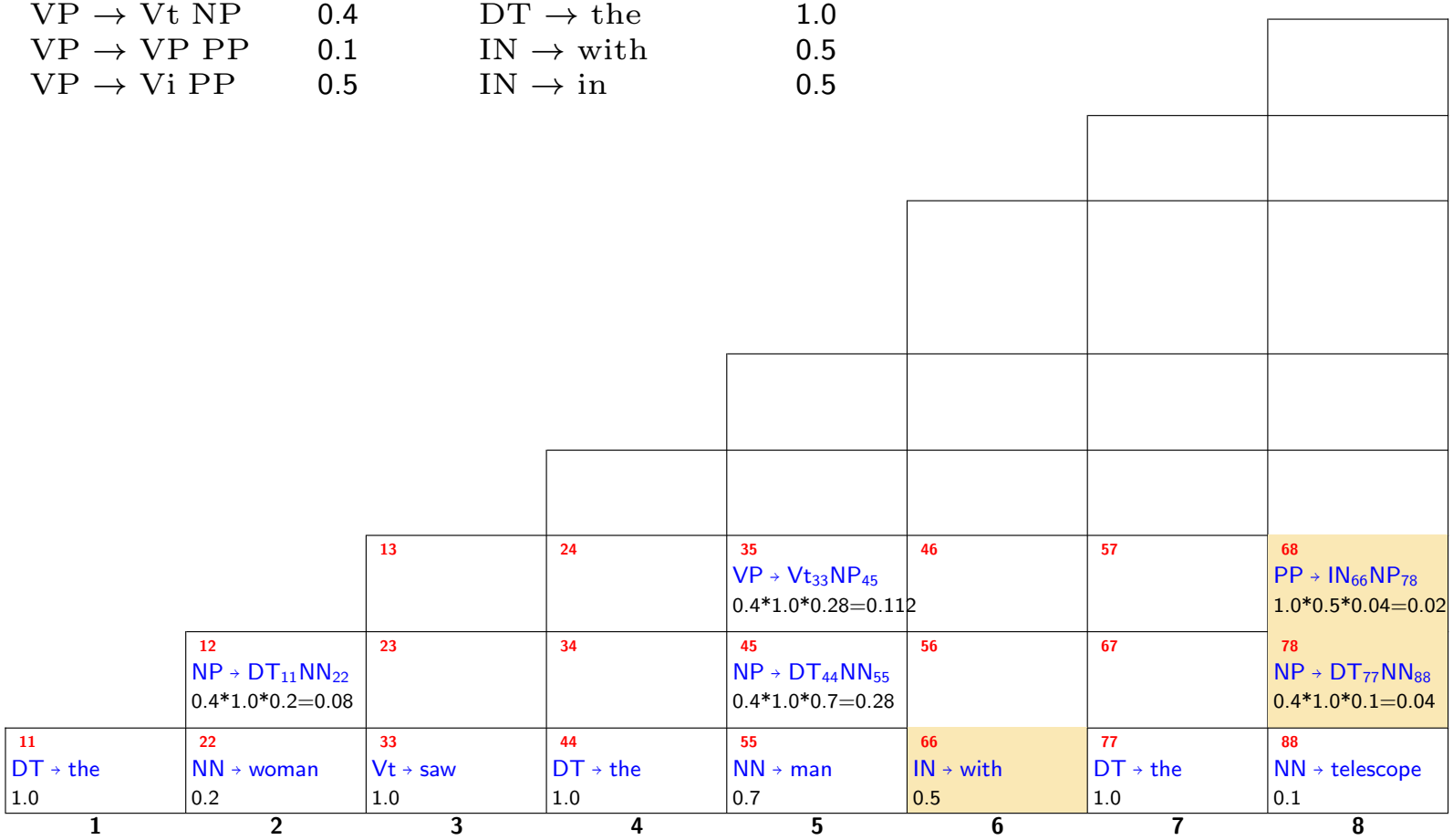
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



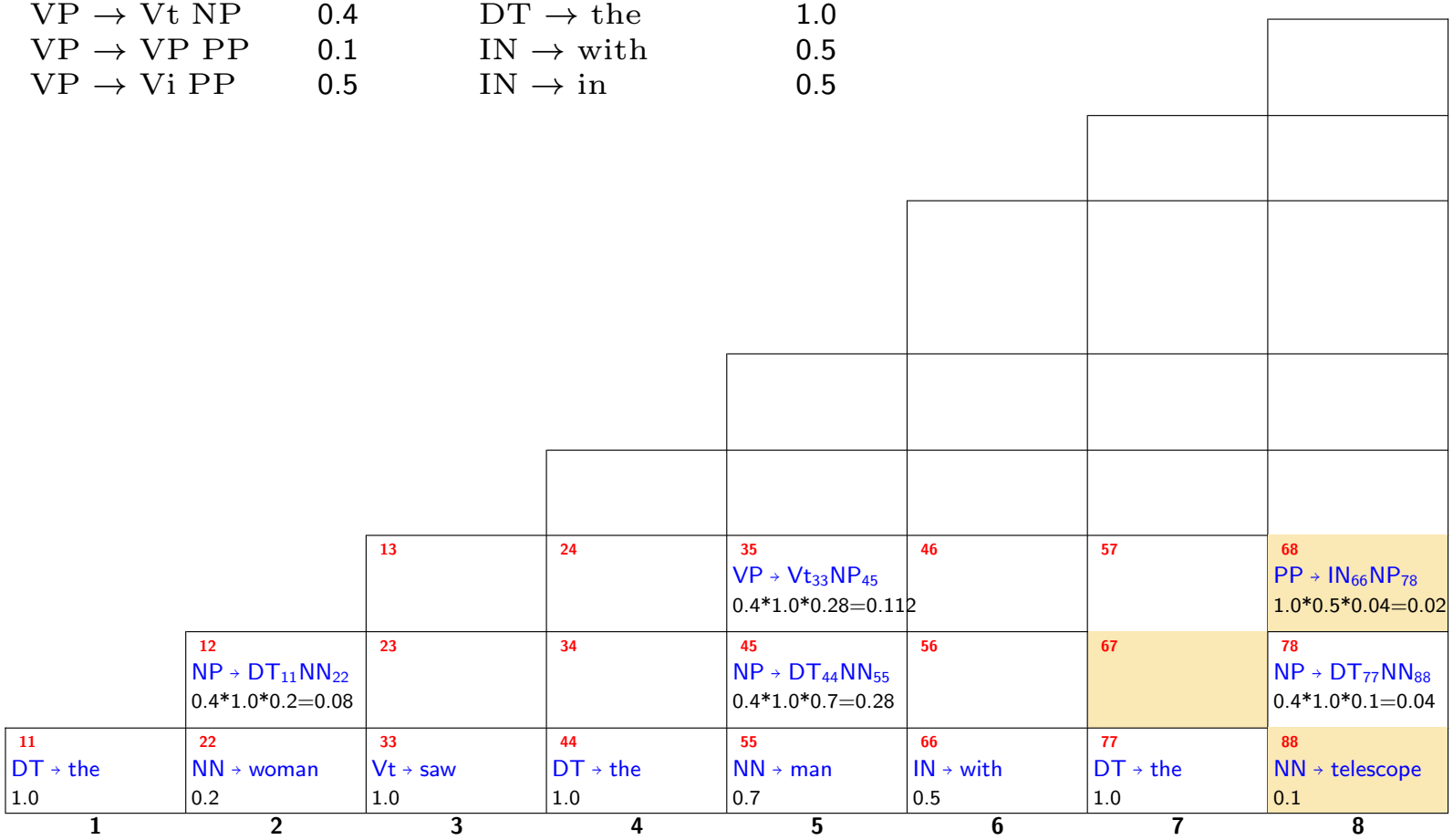
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



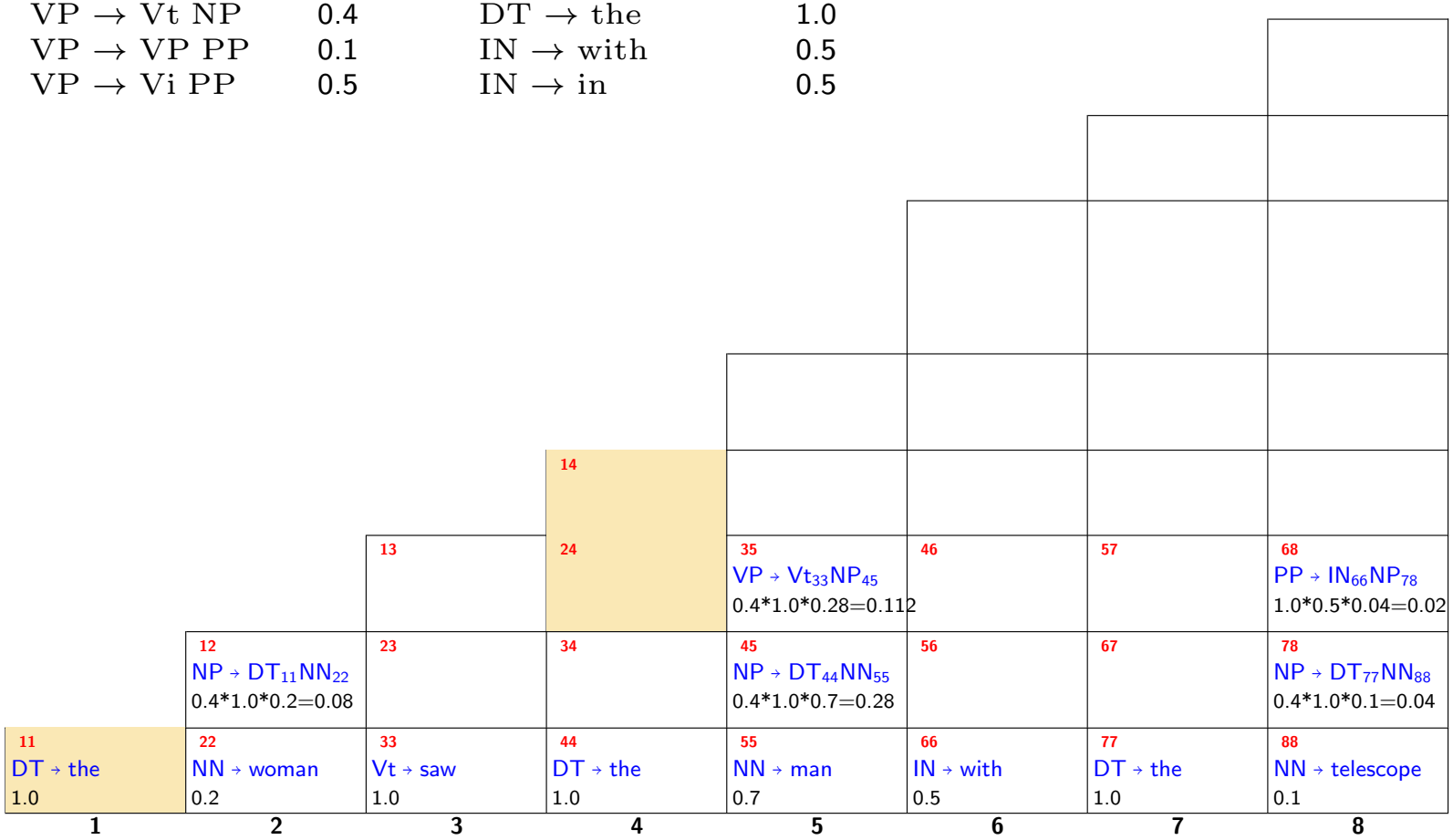
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



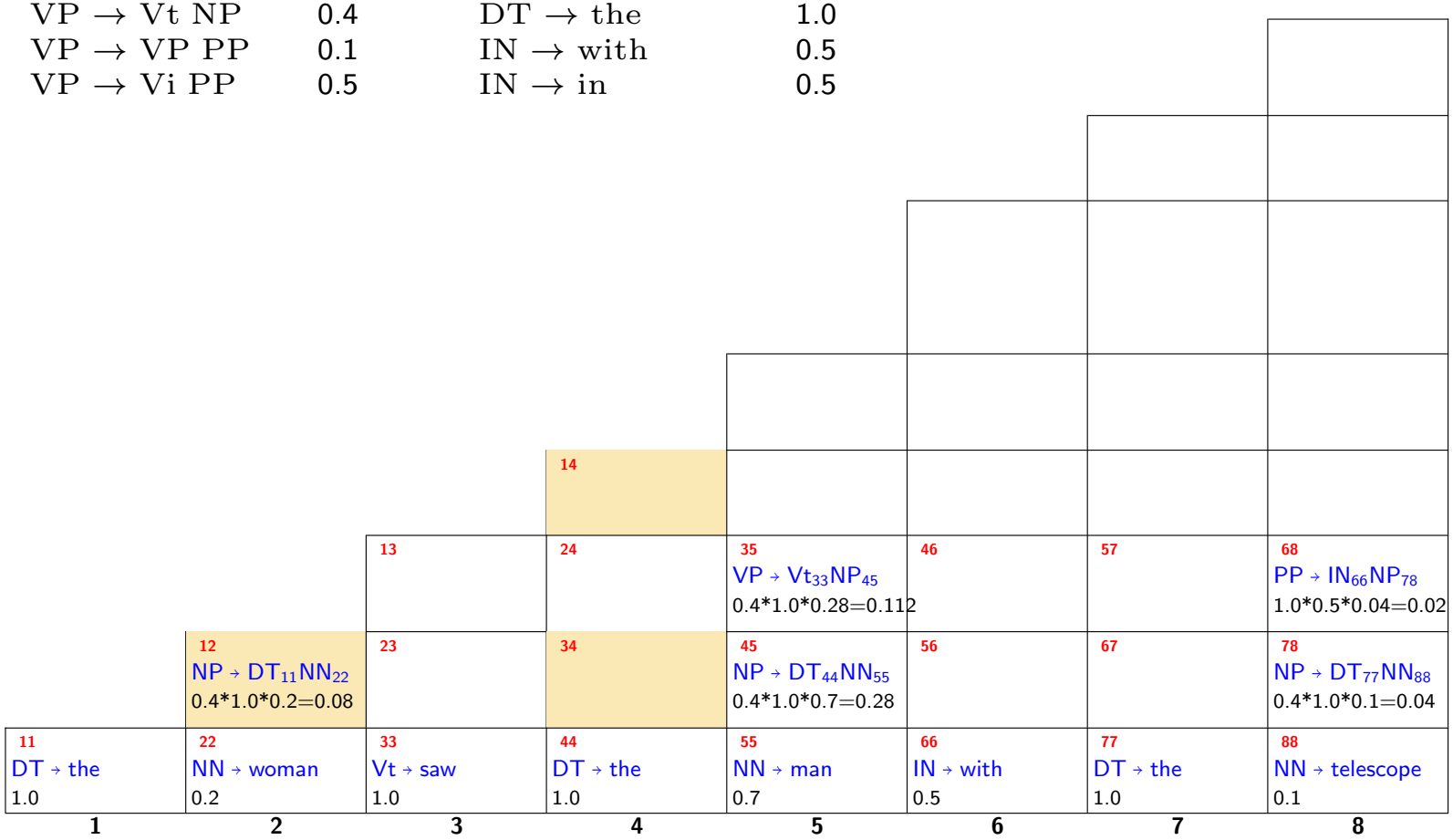
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



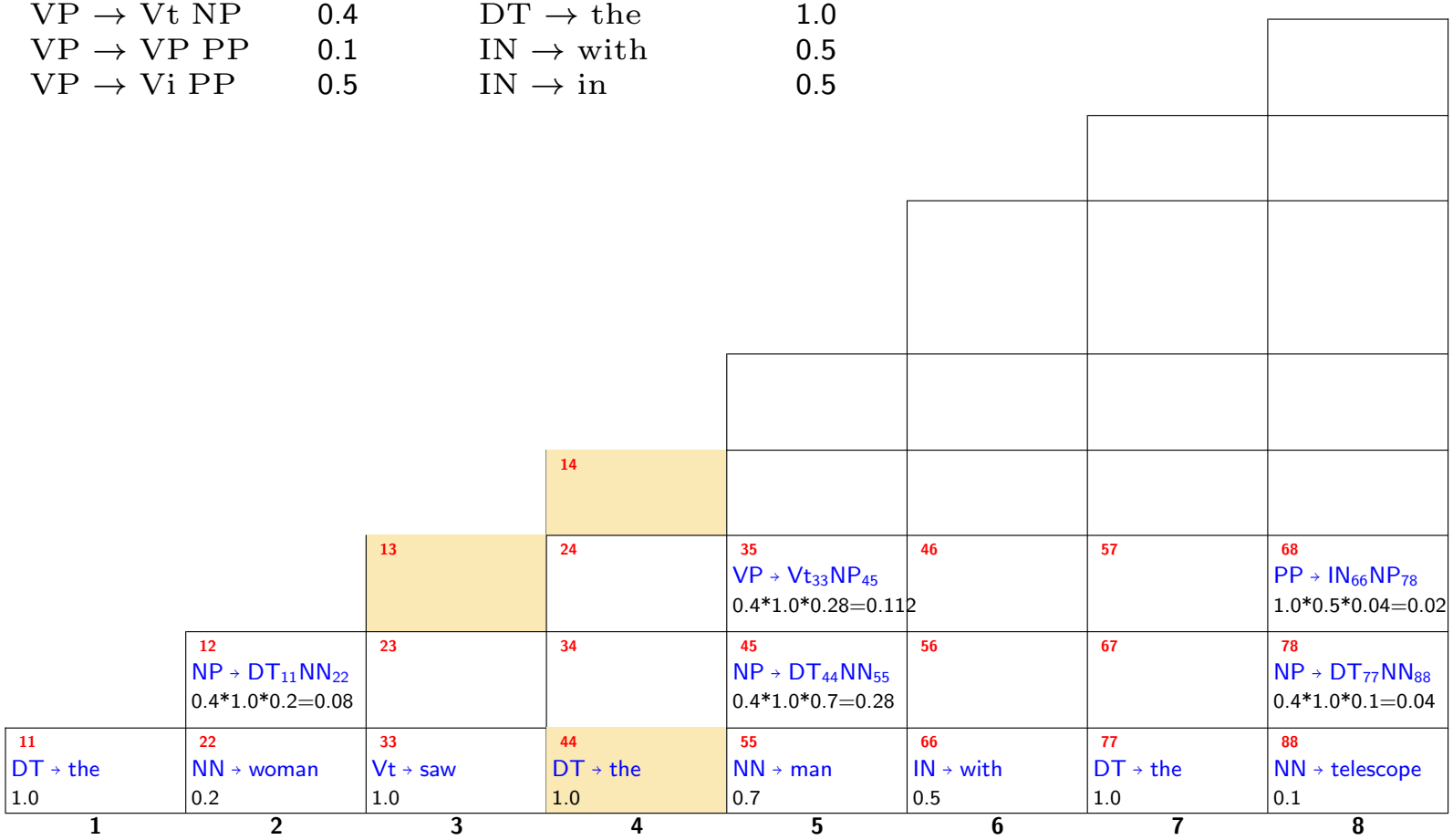
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



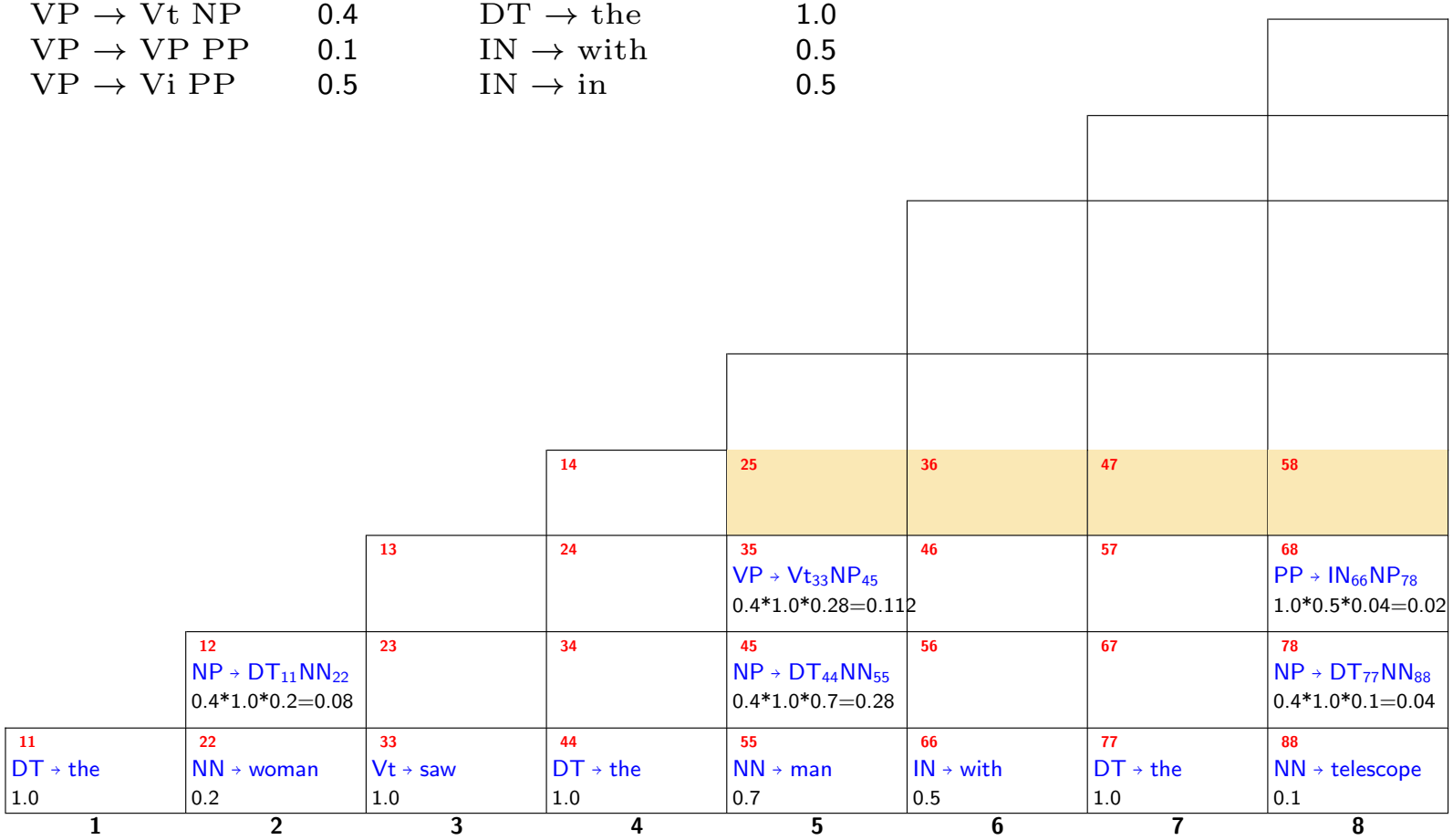
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



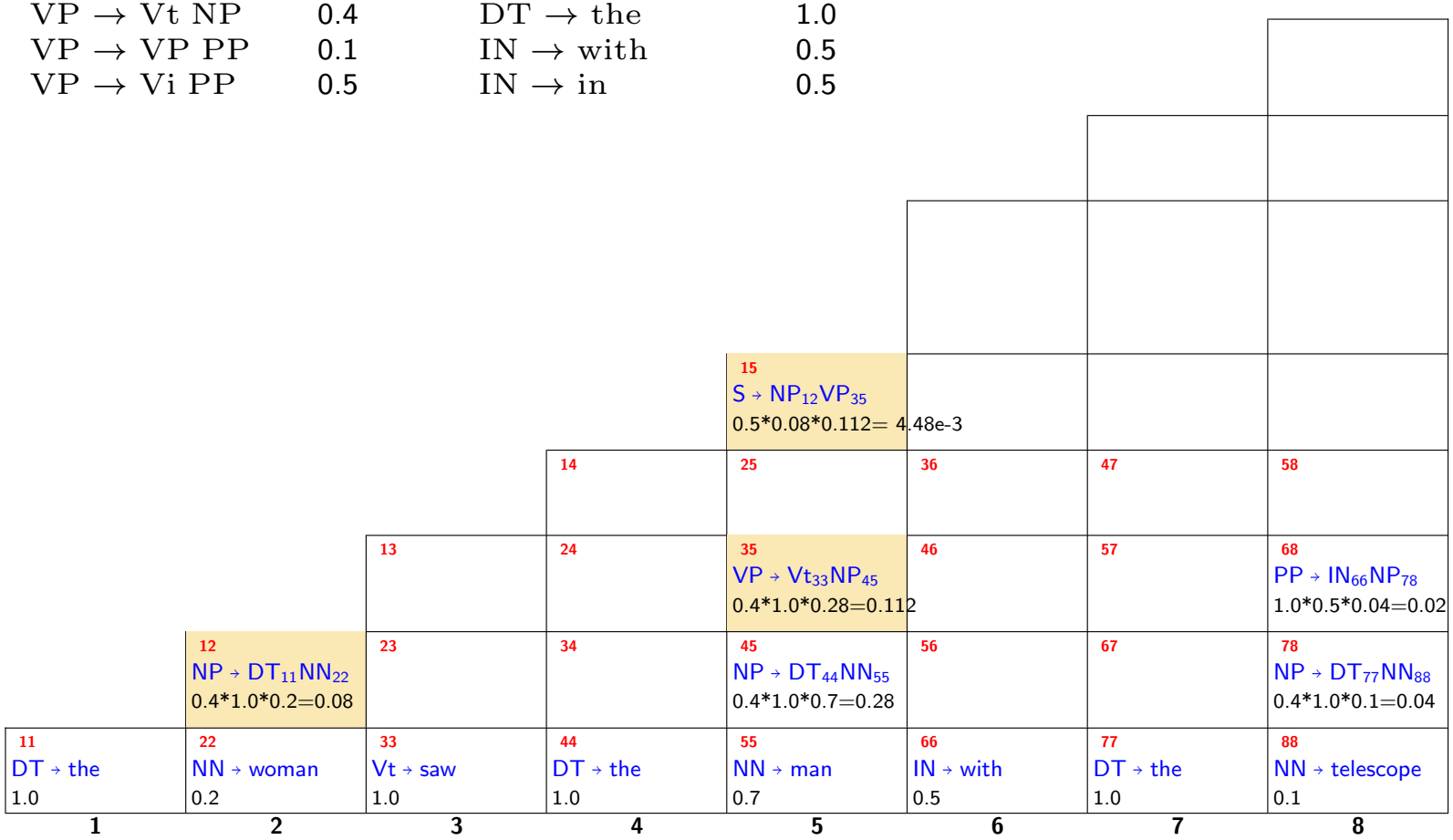
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



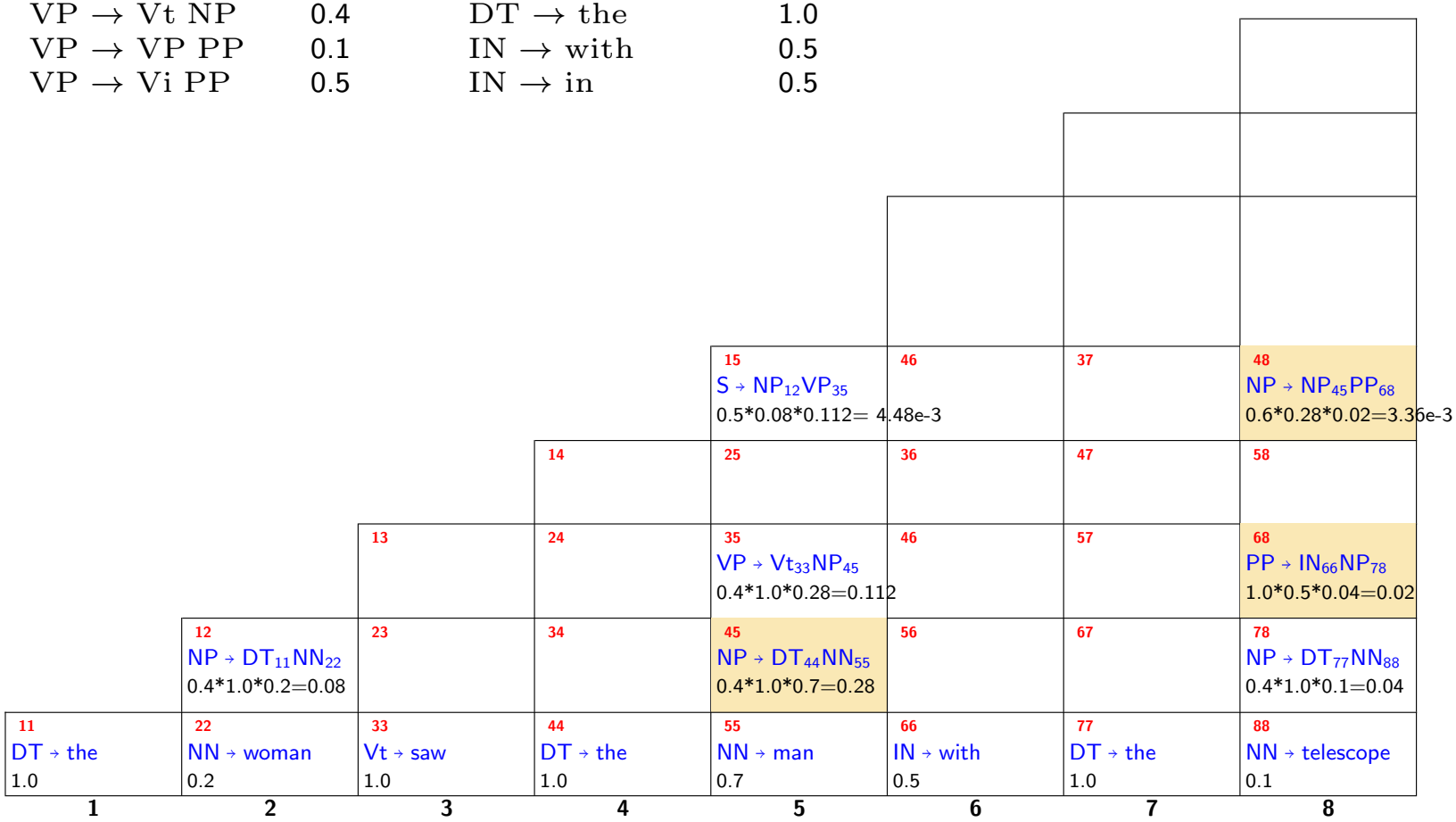
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



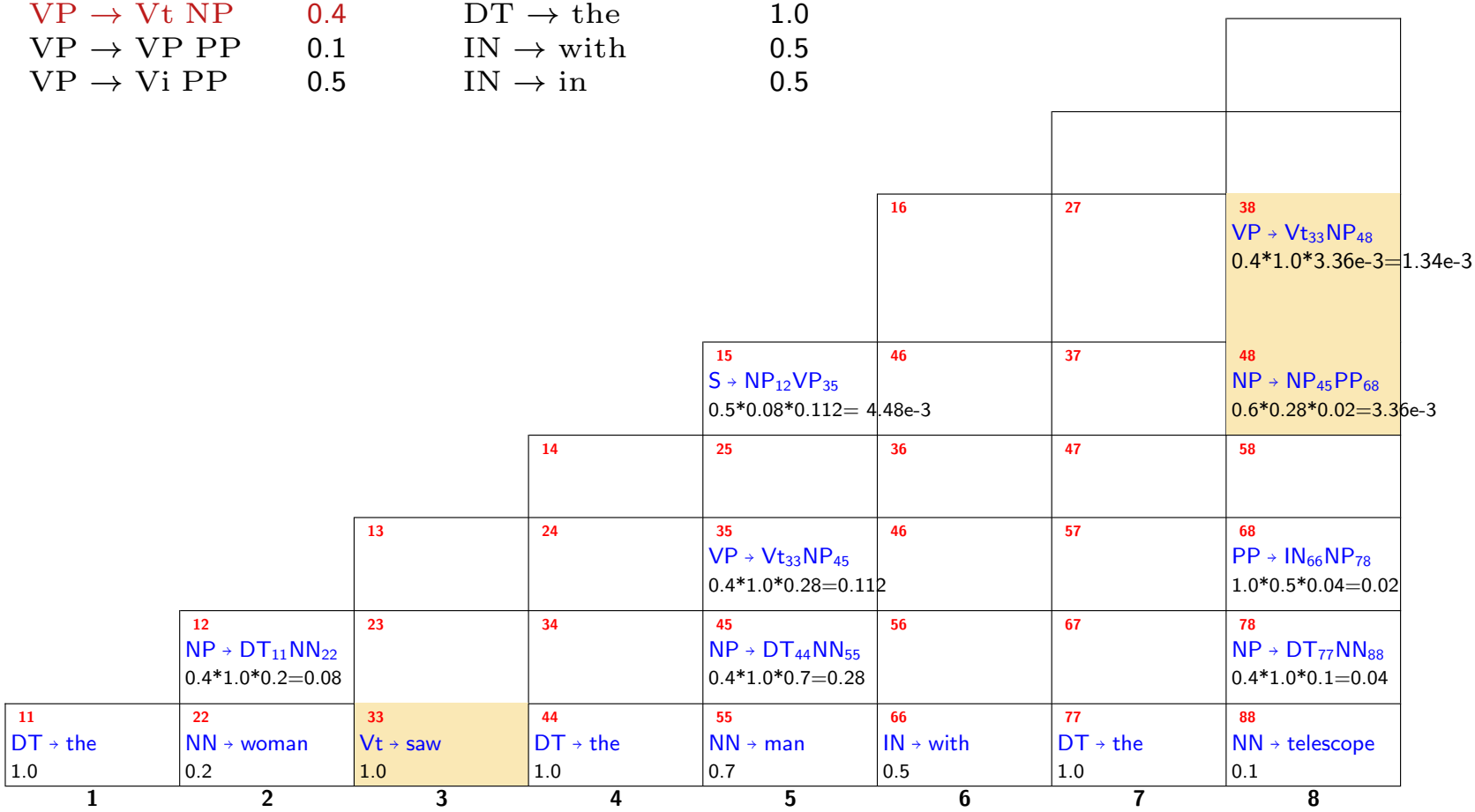
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



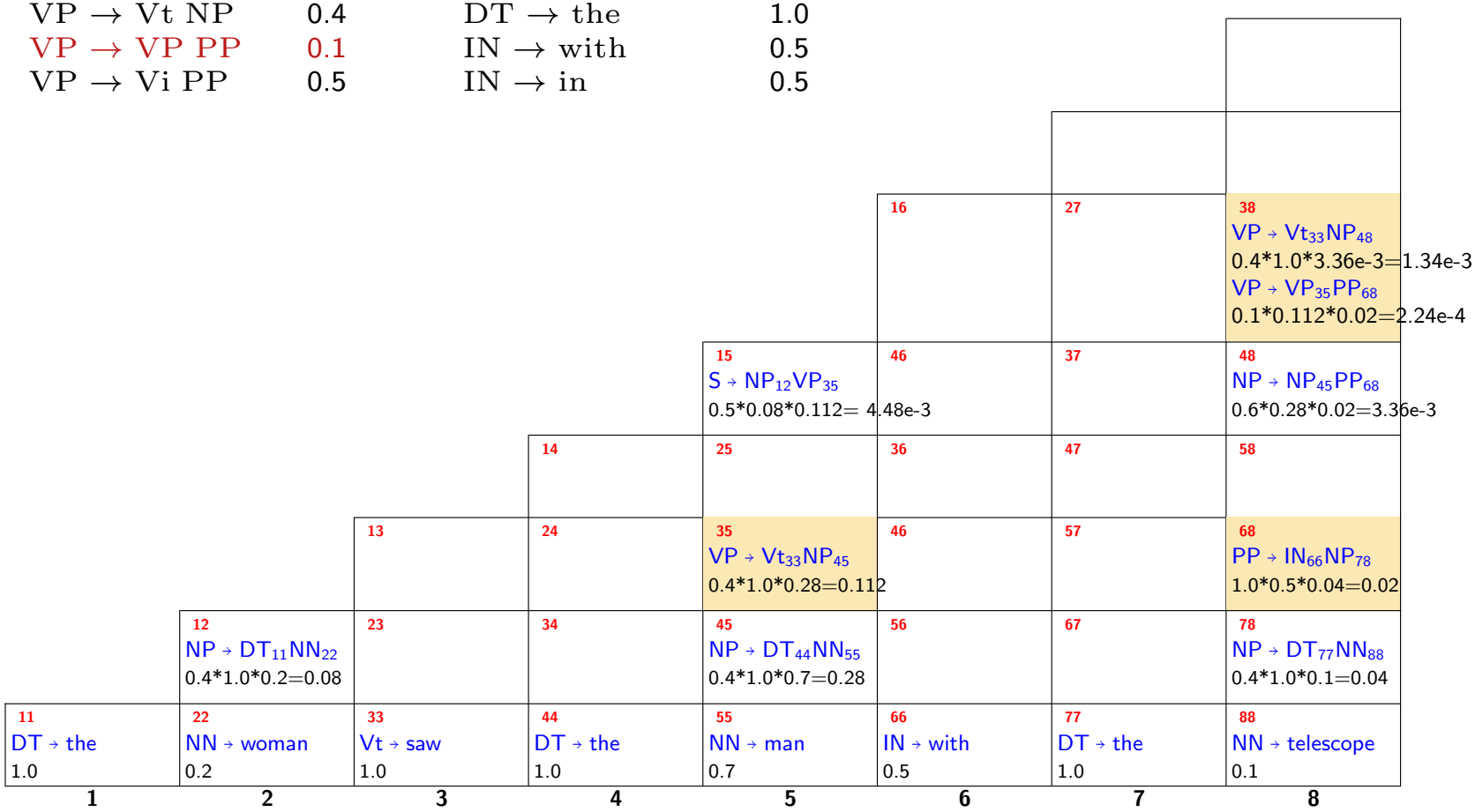
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



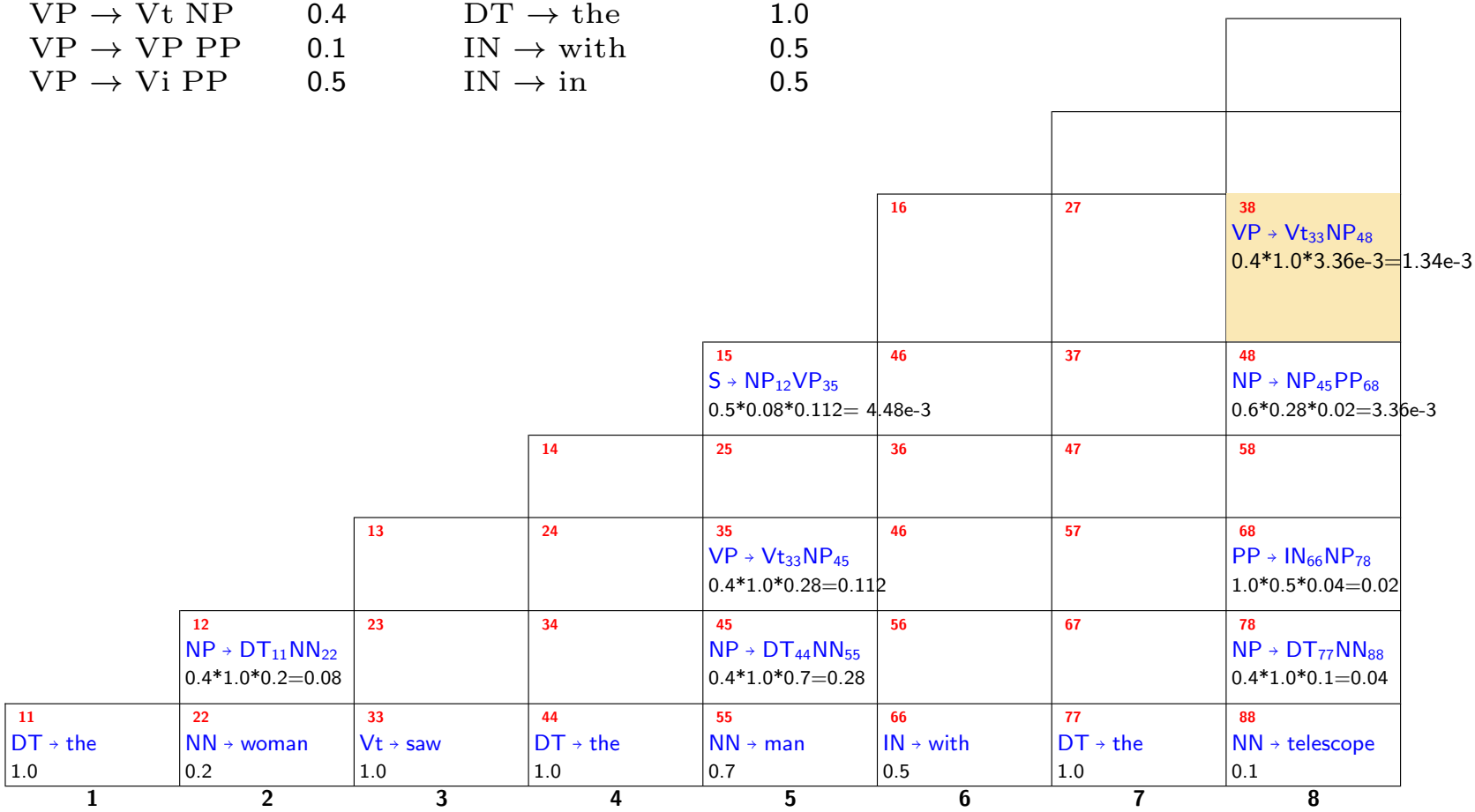
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



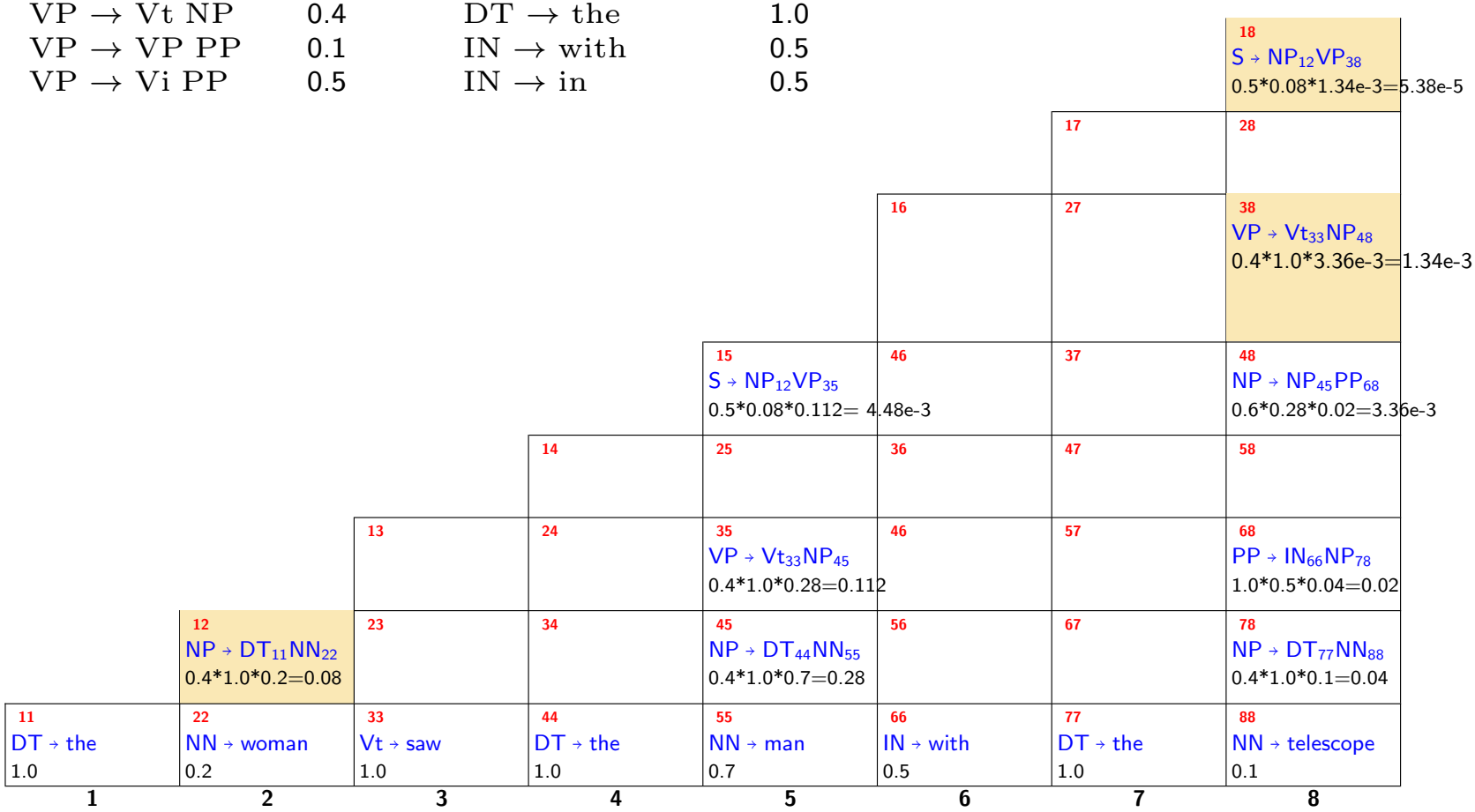
Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5

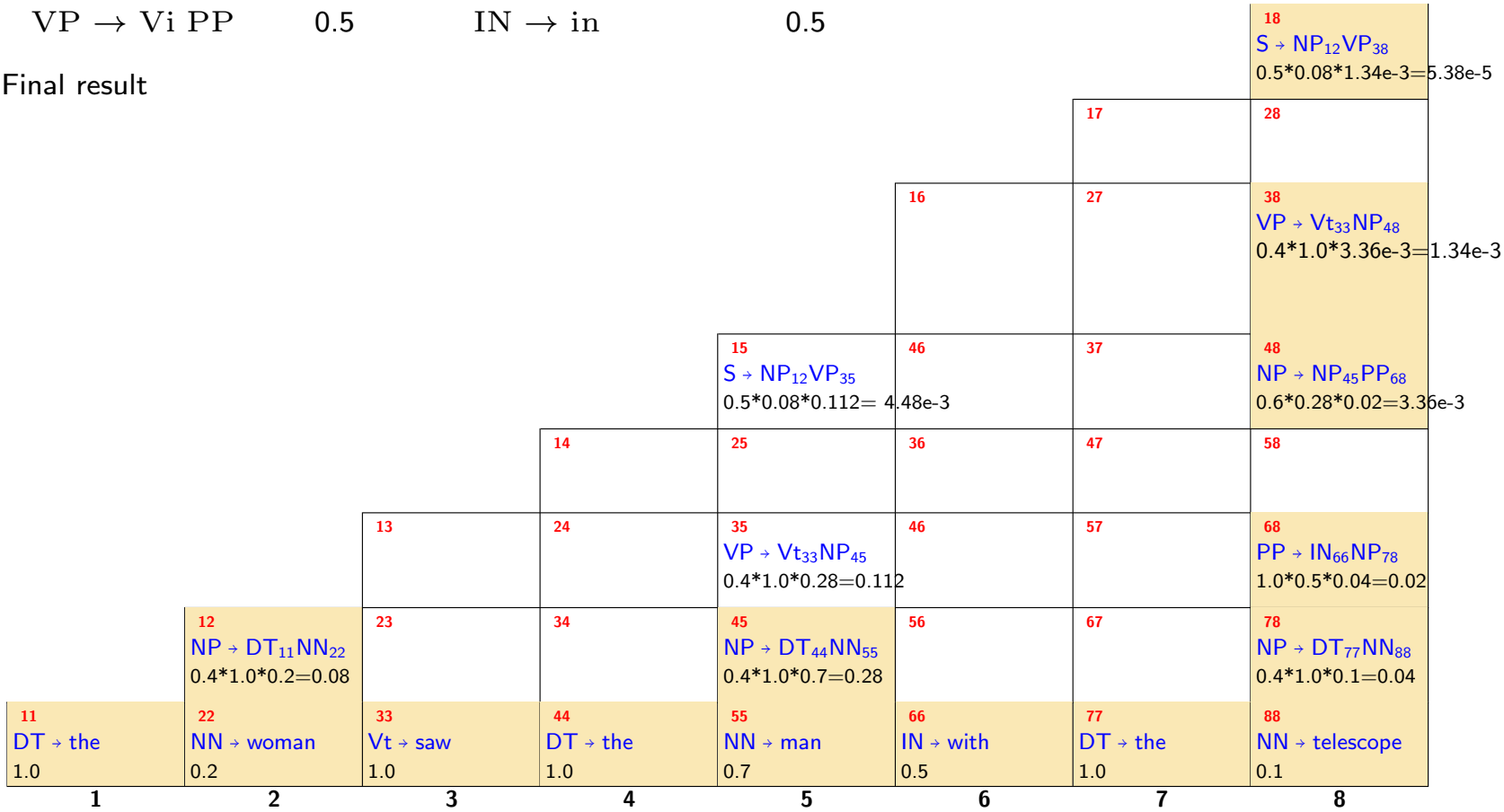


Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5



Exercise 2

S → NP VP	0.5	Vi → sleeps	1.0
S → NP Vi	0.5	Vt → saw	1.0
NP → DT NN	0.4	NN → man	0.7
NP → NP PP	0.6	NN → woman	0.2
PP → IN NP	1.0	NN → telescope	0.1
VP → Vt NP	0.4	DT → the	1.0
VP → VP PP	0.1	IN → with	0.5
VP → Vi PP	0.5	IN → in	0.5

Final result