

The background features a light gray graphic consisting of several overlapping circles and two arrows. One arrow points upwards from the left, and another points towards the upper left from the right. The circles are of varying radii and are partially obscured by the arrows and each other.

# Augmented Transition Networks

Von Anika Westburg

Nach „Augmented Transition Networks as Psychological Models of Sentence Comprehension“, Ronald M. Kaplan, 1972

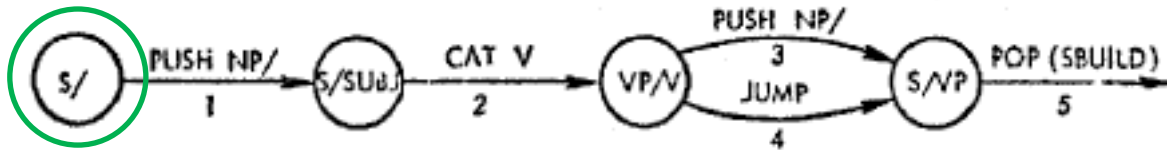
# Eigenschaften ATN

- Wie endliche Automaten mit Speicher
- Zustände bekommen Namen + Operationen auf den Übergängen
- Akzeptanz: Endzustand, Stringende und leerer Speicher
- Rekursive TN (RTN):
  - Push- und Pop-Operationen + Push-Down Store (vgl. PDA)
  - Darstellung verschachtelter, aber nicht überkreuzter Abhängigkeiten
- ATN (RTN mit Register):
  - Register ~ Deep Structure
  - Registeroperationen (SETR, SENDR, ADDR, ...)
  - Angabe weiterer Übergangsbedingungen möglich
  - Überkreuzende Abhängigkeiten
  - Mächtigkeit einer Turingmaschine

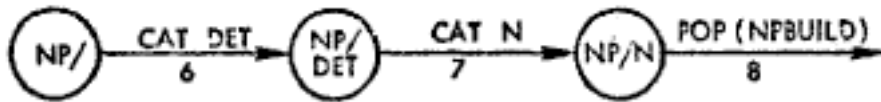
Resteingabe: the man kicked the ball

Push-Down Store

Startzustand (wegen Name)



Register

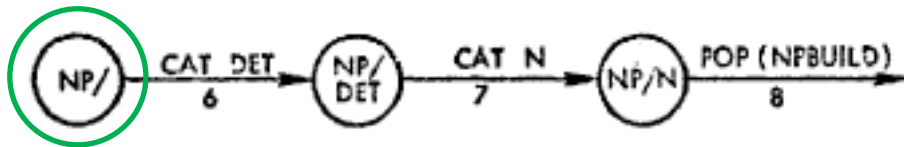
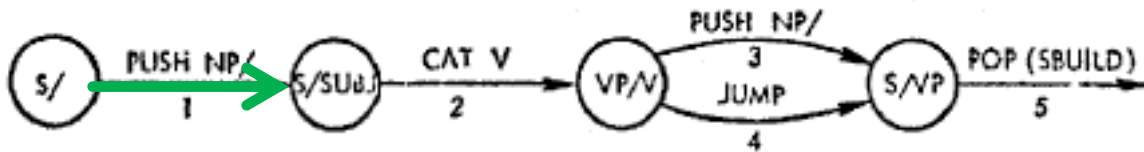


<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Resteingabe: the man kicked the ball

Push-Down Store

Push-Übergang, Springen in Zustand NP/



SUBJ

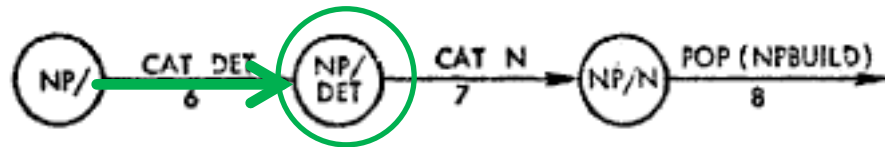
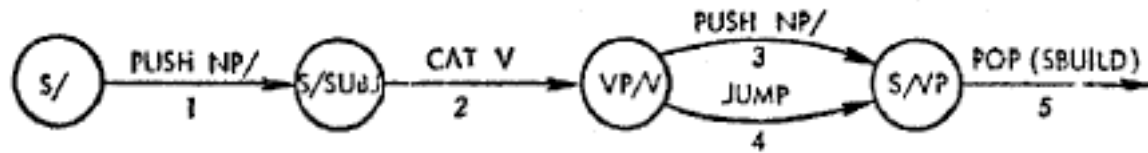
Register

\*

<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
1	T = True	(SETR SUBJ *) = Set Register „SUBJ“ (Platzhalter)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Resteingabe: \_\_\_ man kicked the ball

Eingabewort lesen



Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ ^)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Push-Down Store



Register

SUBJ

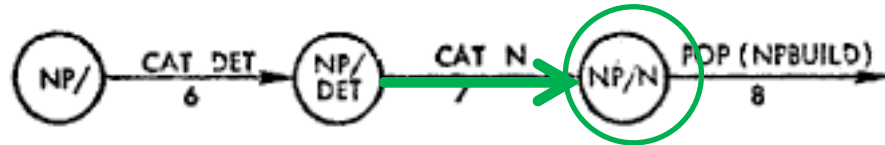
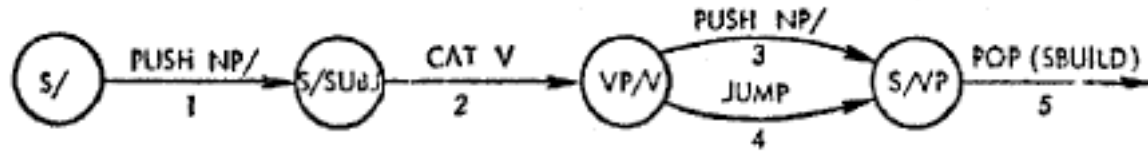
\*

DET

the

Resteingabe: \_\_\_ \_\_\_ kicked the ball

Eingabewort lesen



Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Push-Down Store



Register

SUBJ

\*

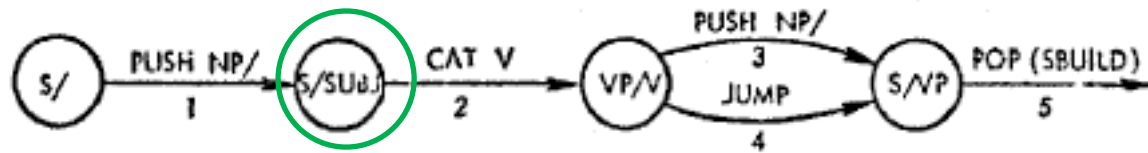
DET

the

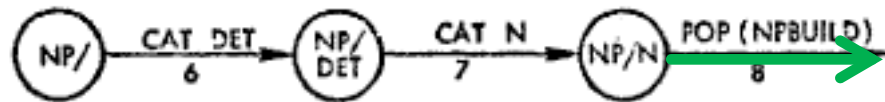
N

man

Resteingabe: \_\_\_\_ \_\_\_\_ kicked the ball



Pop-Übergang, NP zusammensetzen



Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

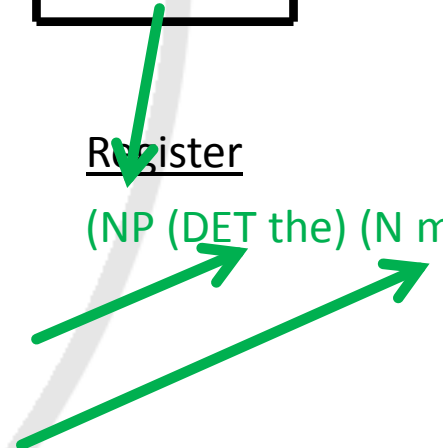
Push-Down Store



Register

SUBJ

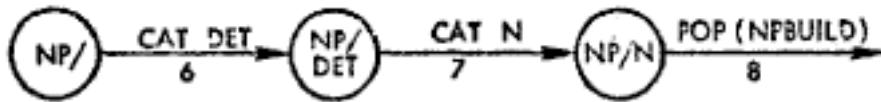
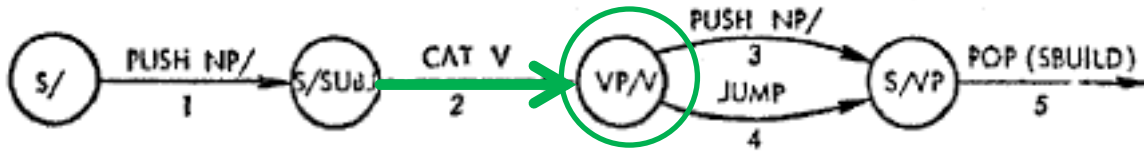
(NP (DET the) (N man))



Resteingabe: \_\_\_\_\_ the ball

Eingabewort lesen

Push-Down Store



Register

SUBJ (NP (DET the) (N man))

TNS PAST

V kick

Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

GETF TNS = Get Form Tense

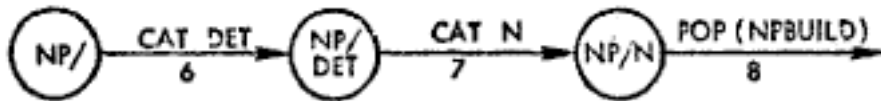
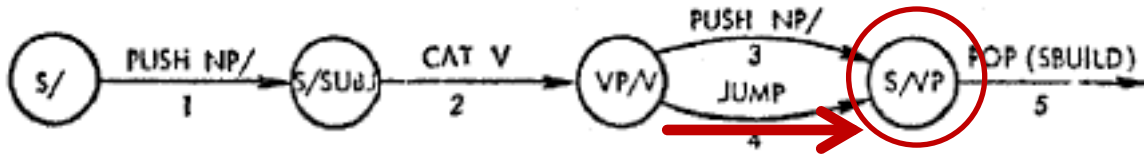
SVAGR = Subjekt Verb Agreement



Resteingabe: \_\_\_\_\_ the ball

Push-Down Store

Jump = optionales Satzglied überspringen



Register

SUBJ (NP (DET the) (N man))

TNS PAST

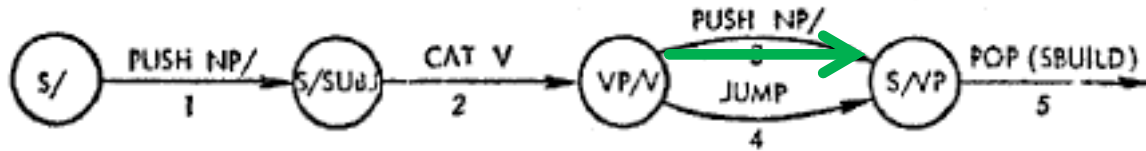
V kick

Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

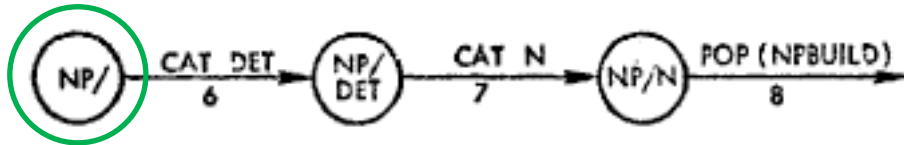
Intransitives Verb: nicht erfüllt

Resteingabe: \_\_\_\_\_ the ball

Push-Übergang



Push-Down Store



Register

SUBJ (NP (DET the) (N man))

TNS PAST

V kick

OBJ \*

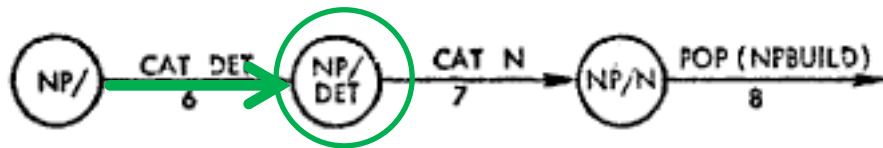
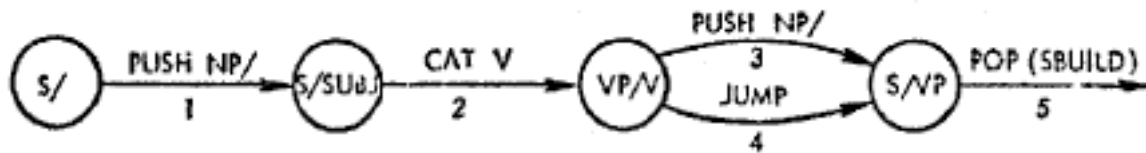
Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Transitives Verb: erfüllt

Resteingabe: \_\_\_\_\_ ball

Eingabewort lesen

Push-Down Store



Register

SUBJ (NP (DET the) (N man))

TNS PAST

V kick

OBJ \*

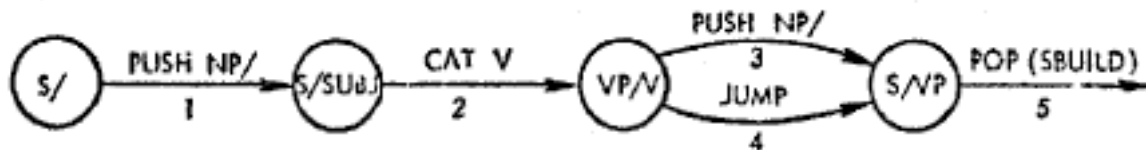
DET the

Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Resteingabe: \_\_\_\_\_

Eingabewort lesen

Push-Down Store



Register

SUBJ (NP (DET the) (N man))

TNS PAST

V kick

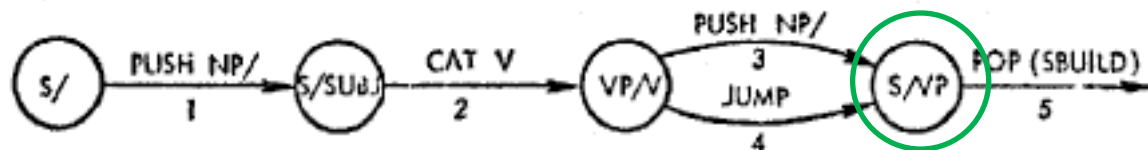
OBJ \*

DET the

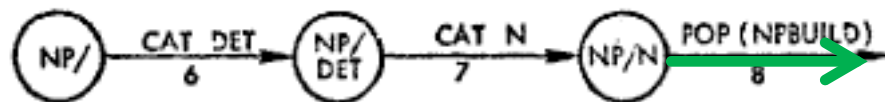
N ball

Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Resteingabe: \_\_\_\_\_



Pop-Übergang, NP zusammensetzen



Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	

Push-Down Store



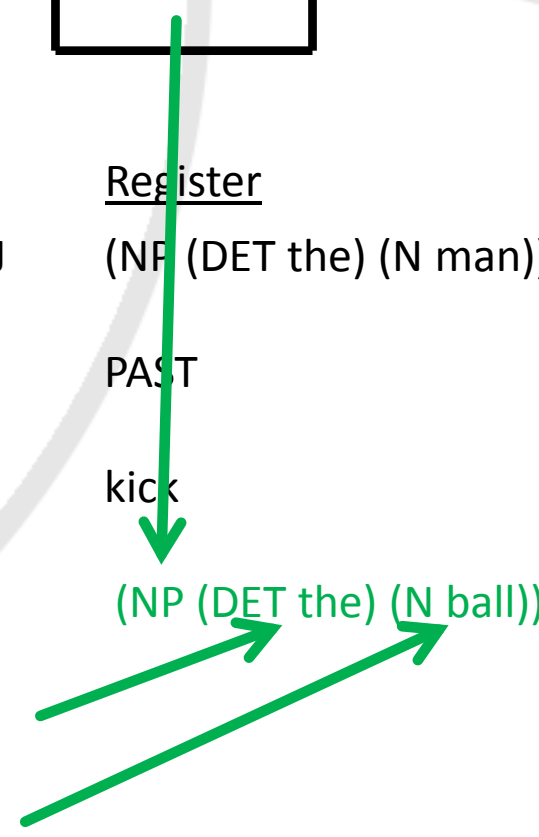
Register

SUBJ (NP (DET the) (N man))

TNS PAST

V kick

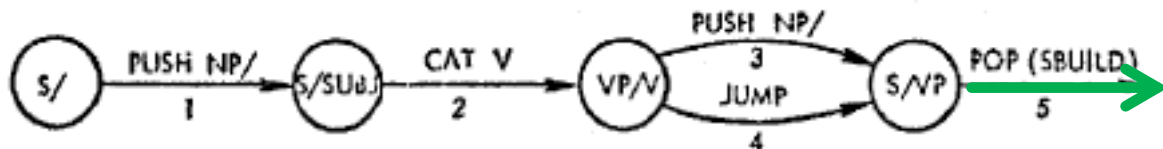
OBJ (NP (DET the) (N ball))



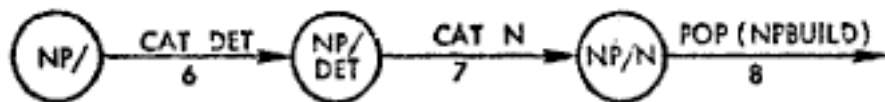
Resteingabe: \_\_\_\_\_

Push-Down Store

Pop-Übergang, S zusammensetzen



Leerer Stack + Endzustand + keine Resteingebe  
= Akzeptanz



Arc	Condition	Actions
1	T	(SETR SUBJ *)
2	(AND (GETF TNS) (SVAGR SUBJ (GETF PNCODE)))	(SETR TNS (GETF TNS)) (SETR V *)
3	(TRANS V)	(SETR OBJ *)
4	(INTRANS V)	
5	T	
6	T	(SETR DET *)
7	T	(SETR N *)
8	T	



Ausgabe

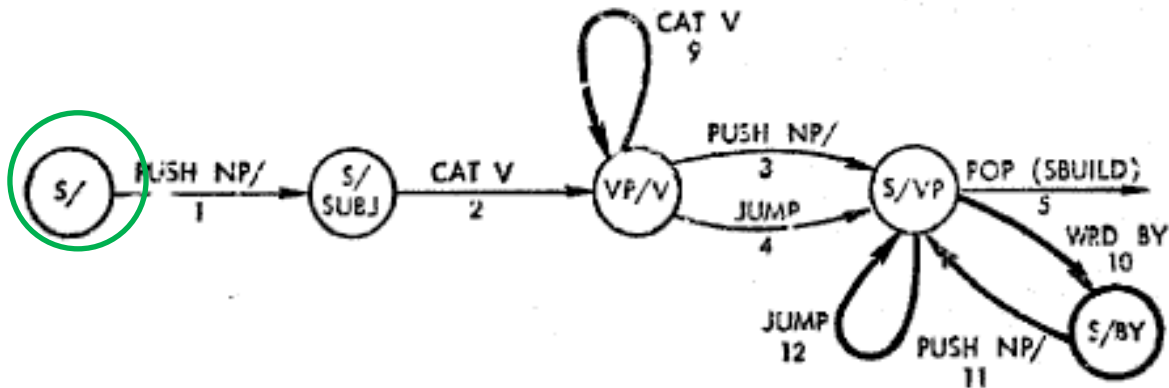
(S  
(NP  
(DET the)  
(N man))  
(AUX  
(TNS PAST))  
(VP  
(V kick)  
(NP  
(DET the)  
(N ball))))

# Weitere Eigenschaften ATN

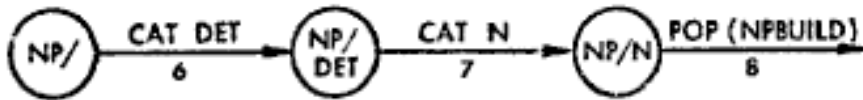
- ATN: "model for sentence comprehension"
  - die relative Schwierigkeit von (5a) vs. 5(b) soll erfasst werden
  - Performanzmodell und Kompetenzmodell sollen zusammenfallen? ("one notation")
- "requirements for adequacy"
  - a.) inkrementelles Parsen
  - b.) lineare (?) Parsingzeit ("slowly increasing function of sentence length")
  - c.) psycholinguistisch angemessen bei Ambiguität (depth-first, d.h. seriell)
- Nähe zur Transformationsgrammatik
  - Transformation = Registerüberschreibung
  - DTC soll gelten
- Maß für Komplexität:
  - Anzahl der versuchten Übergänge
  - Anzahl der Registeraktivitäten
  - [DTC auch ein Problem für ATNs?]

Resteingabe: The ball was kicked by the man

Push-Down Store



Register

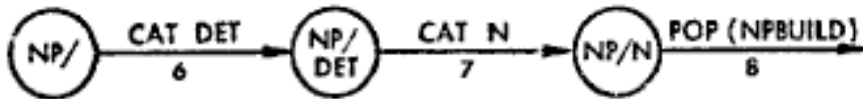
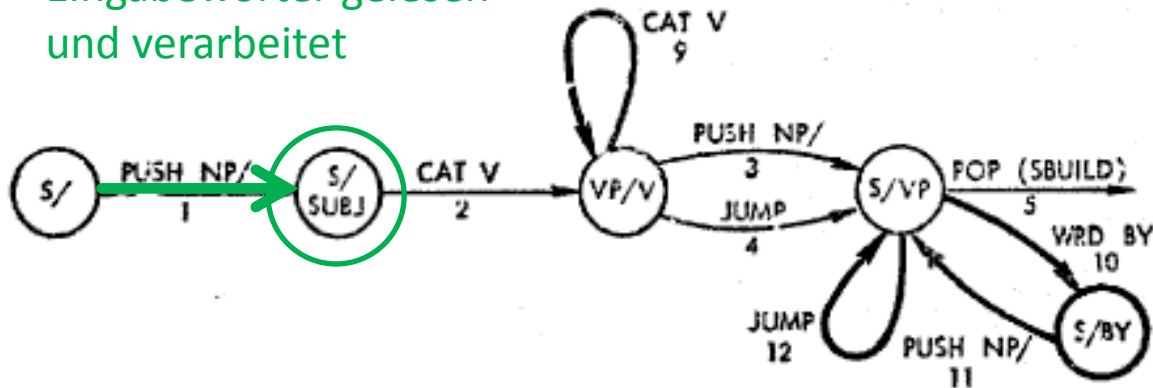


<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))



Resteingabe: \_\_\_\_\_ was kicked by the man

Eingabewörter gelesen  
und verarbeitet



<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Push-Down Store



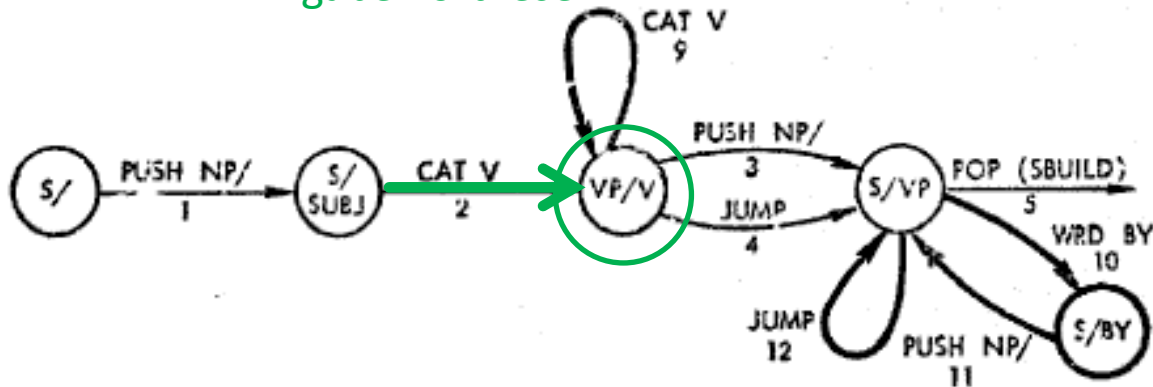
Register

SUBJ

(NP (DET the) (N ball))

Resteingabe: \_\_\_\_\_ kicked by the man

Eingabewort lesen



Push-Down Store

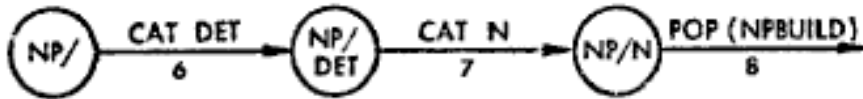


Register

SUBJ (NP (DET the) (N ball))

TNS PAST

V be

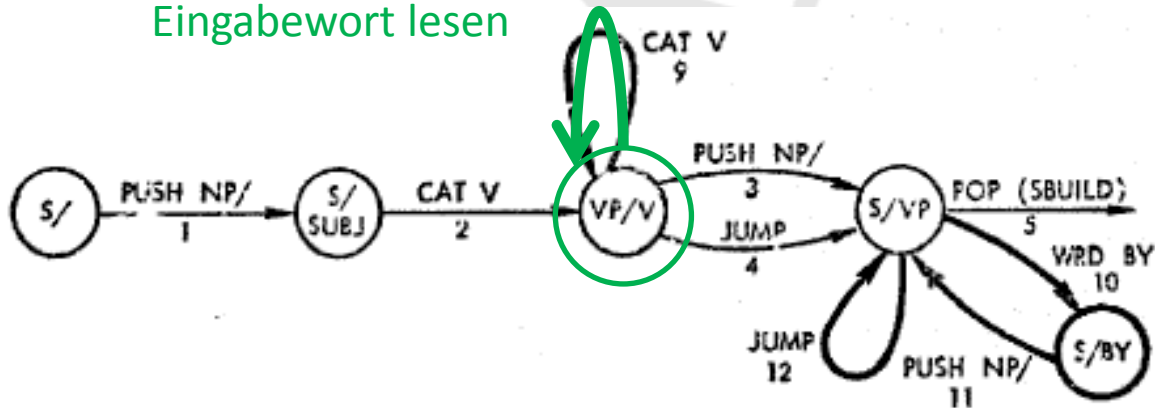


Arc	Condition	Actions
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

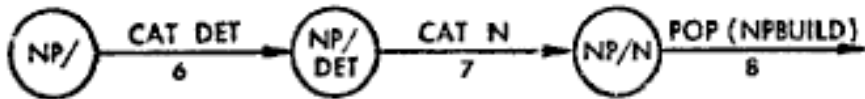
-> unklar, ob „was“ passiv oder past markiert, aber erstmal als past erfasst

Resteingabe: \_\_\_\_\_ by the man

Eingabewort lesen



Push-Down Store



Register

SUBJ NIL  
 OBJ (NP (DET the) (N ball))  
 TNS PAST  
 V kick

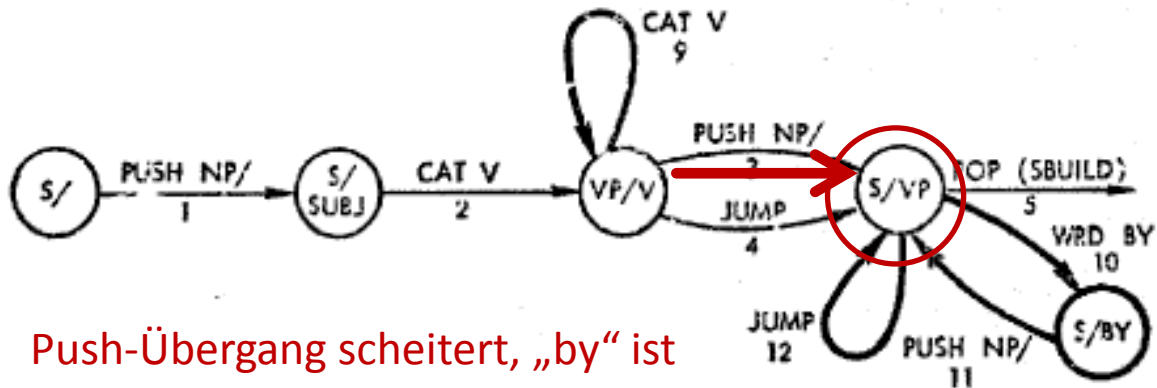
Arc	Condition	Actions
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)

10 (NULLR SUBJ)  
 11 T (SETR SUBJ \*)  
 12 (NULLR SUBJ) (SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

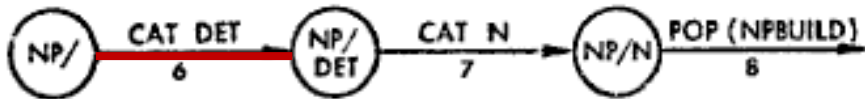
GETF PASTPAR = ist „kicked“ Past Partizip?  
 PASSIVE \* = ist kicked passiv?  
 WRD BE V = Word „be“ als Verb im Register?

Resteingabe: \_\_\_\_\_ by the man

Push-Down Store



Push-Übergang scheitert, „by“ ist nicht DET



Register

SUBJ

NIL

OBJ

(NP (DET the) (N ball))

TNS

PAST

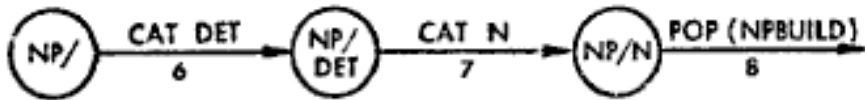
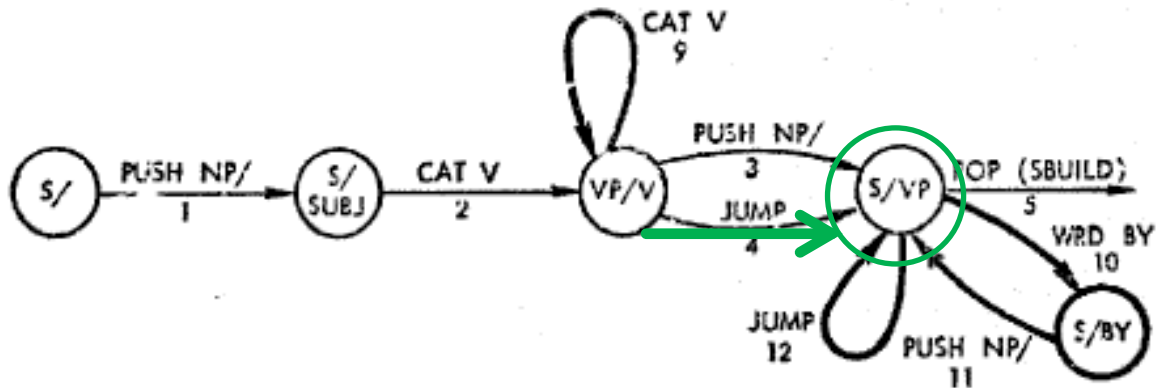
V

kick

<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Resteingabe: \_\_\_\_\_ by the man

Push-Down Store



Register

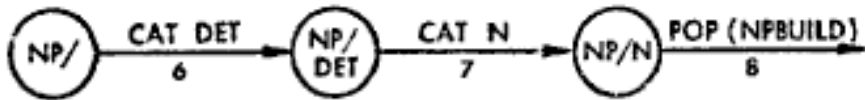
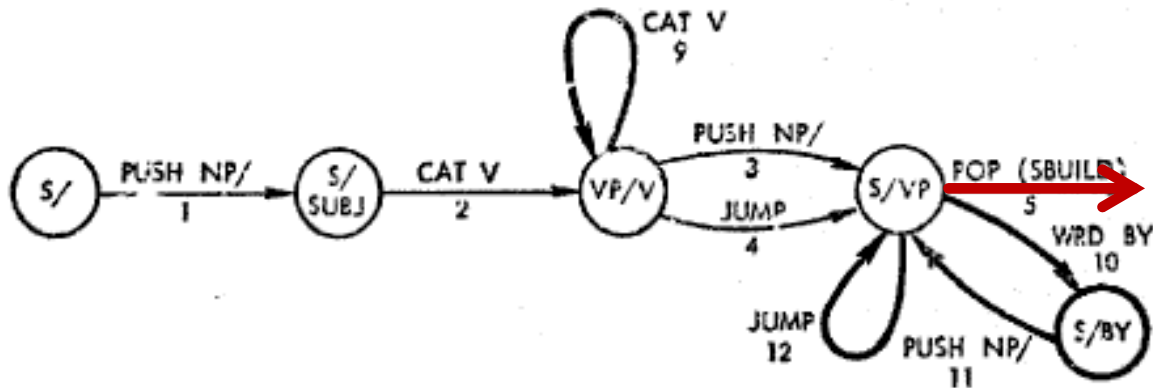
SUBJ	NIL
OBJ	(NP (DET the) (N ball))
TNS	PAST
V	kick

FULLR OBJ = Full Register OBJ

<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Resteingabe: \_\_\_\_\_ by the man

Push-Down Store



Register

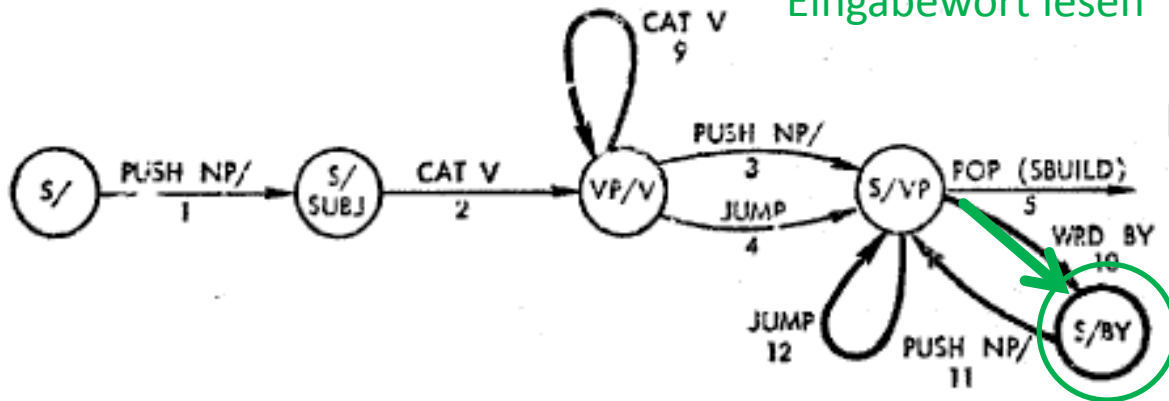
SUBJ	NIL
OBJ	(NP (DET the) (N ball))
TNS	PAST
V	kick

<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	<b>FULL Register SUBJ nicht erfüllt</b>
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Resteingabe: \_\_\_\_\_ the man

Push-Down Store

Eingabewort lesen



Register

SUBJ

NIL

OBJ

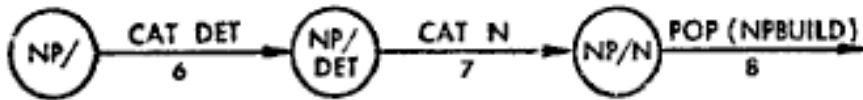
(NP (DET the) (N ball))

TNS

PAST

V

kick



Arc	Condition	Actions
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)

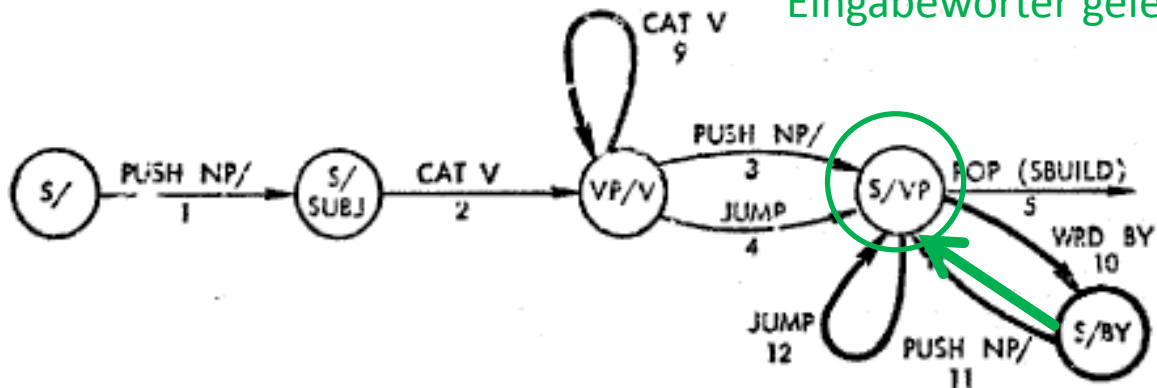
10 (NULLR SUBJ) NULLR SUBJ = NULLR ist wahr wenn FULLR NIL ist

11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Resteingabe: \_\_\_\_\_

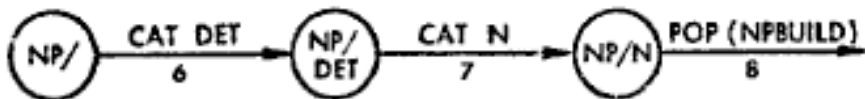
Push-Down Store

Eingabewörter gelesen



Register

SUBJ (NP (DET the) (N man))  
 OBJ (NP (DET the) (N ball))  
 TNS PAST  
 V kick



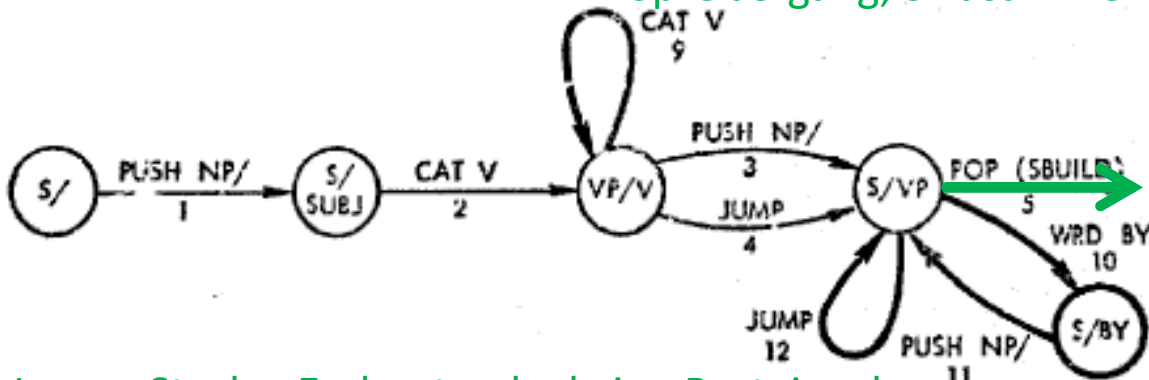
<u>Arc</u>	<u>Condition</u>	<u>Actions</u>
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))



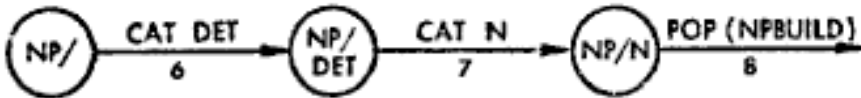
Resteingabe: \_\_\_\_\_

Push-Down Store

Pop-Übergang, S zusammensetzen



Leerer Stack + Endzustand + keine Resteingabe  
= Akzeptanz



Arc	Condition	Actions
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

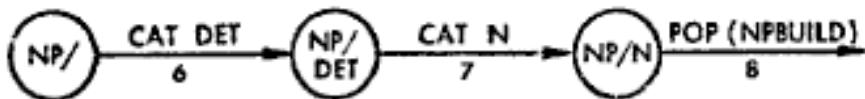
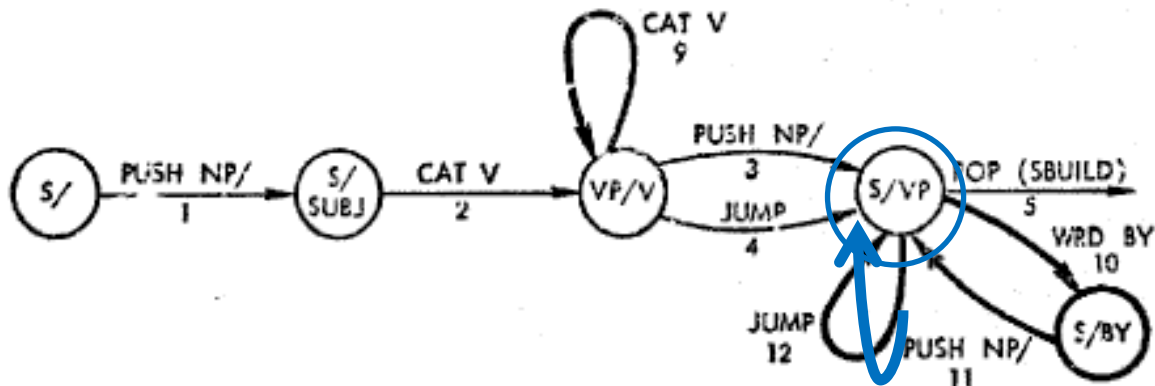


Ausgabe

(S  
(NP  
(DET the)  
(N man))  
(AUX  
(TNS PAST))  
(VP  
(V kick)  
(NP  
(DET the)  
(N ball))))

Resteingabe: \_\_\_\_\_

Push-Down Store



Register

SUBJ (NP (PRO someone))  
 OBJ (NP (DET the) (N ball))  
 TNS PAST  
 V kick

Arc	Condition	Actions
4	(OR (!INTRANS V) (FULLR OBJ))	
5	(FULLR SUBJ)	
9	(AND (GETF PASTPART) (PASSIVE *) (WRD BE V))	(SETR OBJ SUBJ) (SETR SUBJ NIL) (SETR V *)
10	(NULLR SUBJ)	
11	T	(SETR SUBJ *)
12	(NULLR SUBJ)	(SETR SUBJ (QUOTE (NP (PRO SOMEONE))))

Ohne Subjekt: füge „someone“ ein

# Anwendung/ Kritik

- ATNs verarbeiten den Eingabestring stark inkrementell.
- "ATNs were successful, and large and impressive systems were built using them (in fact, for many years the ATN underlying the LUNAR system was probably the largest natural language processing system in the world). Secondly, at the time, ATNs did not merely seem a useful practical tool, they seemed theoretically motivated as well." (Blackburn, Stregnitz)
- Kritik: Warum es sie heute kaum noch gibt.
  - Mächtigkeit von TM
  - schwer zu pflegen (v.a. wegen Registerzugriffe)
  - erben die Probleme der Transformationsgrammatik bzgl. DTC?
  - besser für Sprachen mit fester Wortstellung und wenig Morphologie

The background features several light gray, curved lines and arrows. One arrow points upwards from the left, another points to the left from the top, and a third points downwards from the right. The lines are smooth and intersect to create a sense of movement and flow.

**Danke für eure Aufmerksamkeit**