Introducing the grammar network

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Lake Como Summer School 2019

Brief review

- Grammar is best understood as dynamic system shaped domain-general processes of language use.
- The goal is to exlain the emergence of language structure and the dynamics of the system.

➢ To this end, we use a network approach because network models are very well-suited to explain dynamic and self-organizing processes.

Architecture of the grammar network

Signs (i.e. constructions) as networks:

- Symbolic relations
- Sequential relations
- Taxonomic relations

Networks of signs:

- Lexical relations
- Constructional relations
- Filler-slot relations

Taxonomic relations

Taxonomic relations

All aspects of linguistic knowledge are ultimately based on language users' experience with lexical expressions.

But linguistic knowledge exceeds our memory of lexical tokens.

Grammar includes "constructional schemas" that are derived from strings of lexical expressions.

Since schemas are derived from lexical sequences, they are associated with particular lexical items.

The result of this is a "taxonomic network" (Goldberg 2006).

Taxonomic relations

CONSTRUCTIONAL SCHEMA

[ ]N/P [ ]N

P.PRO [ ]N   [ ]N s [ ]N

my   love   your   turn   girl 's day   boy 's club

GENITIVE CONSTRUCTION
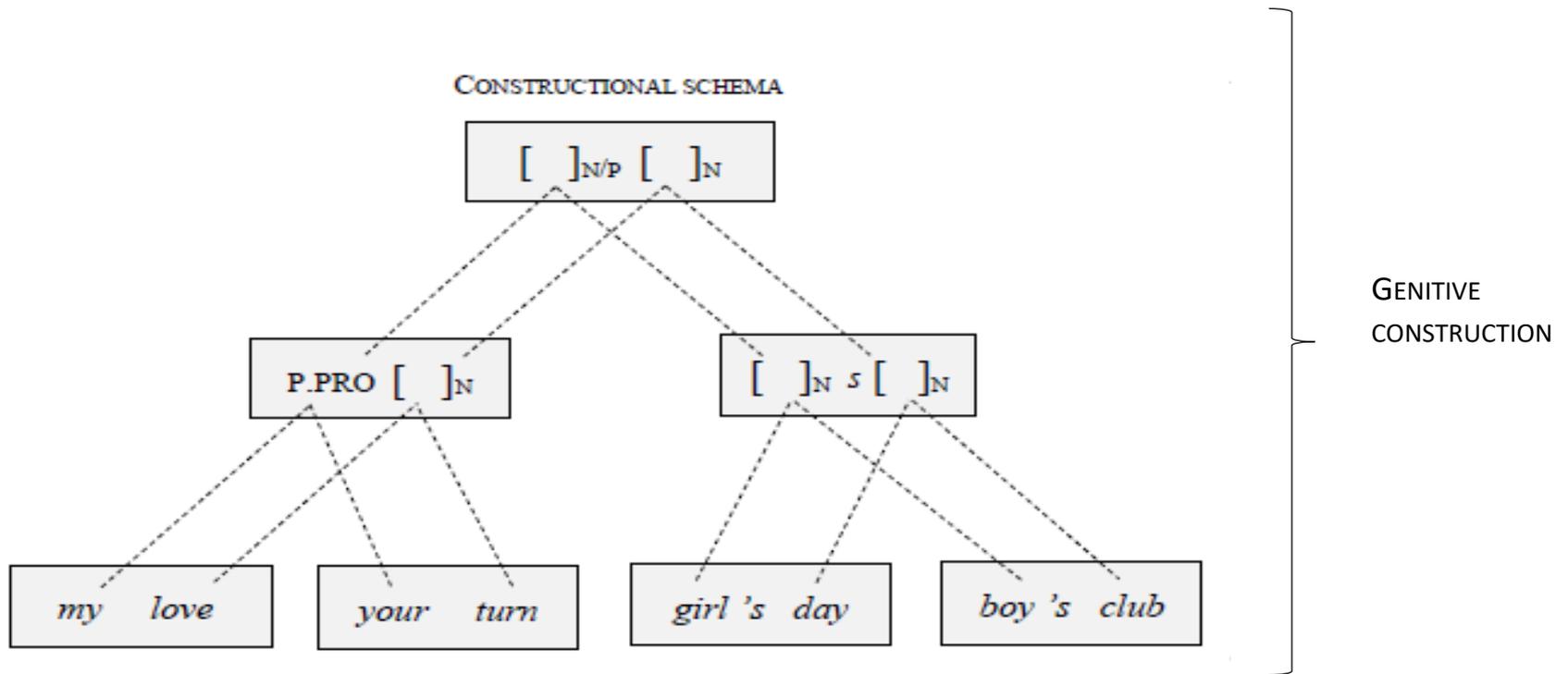
Statistical grammar learning in infancy

Infant research

Research on "schema extraction" in infancy (Marcus et al. 1999; Gómze and Gerken 1999, 2000; Gerken 2006; Saffran 2009; Newport and Aslin 2012 and many others)

Gómez and Gerken 1999

12-month-old infants were exposed to an **artificial language** consisting of …

- Set of nonce words (of the form CVC)
- Set of constructions (word order + number of words)

Training set

CIP   BOK   GEL

BOK   VUN   BOK   GEL

BOK   VUN   GEL   TAG   VUN   TAG

BOK   VUN   GEL   TAG   VUN   GEL

CIP   BOK   BOK   BOK   GEL   TAG   VUN

Gómez and Gerken 1999

After training, infants listened to two different sets of stimuli:

Condition 1

VOT PEL JIC

PEL TAM PEL JIC

PEL TAM JIC RUD TAM RUD

PEL TAM JIC RUD TAM JIC
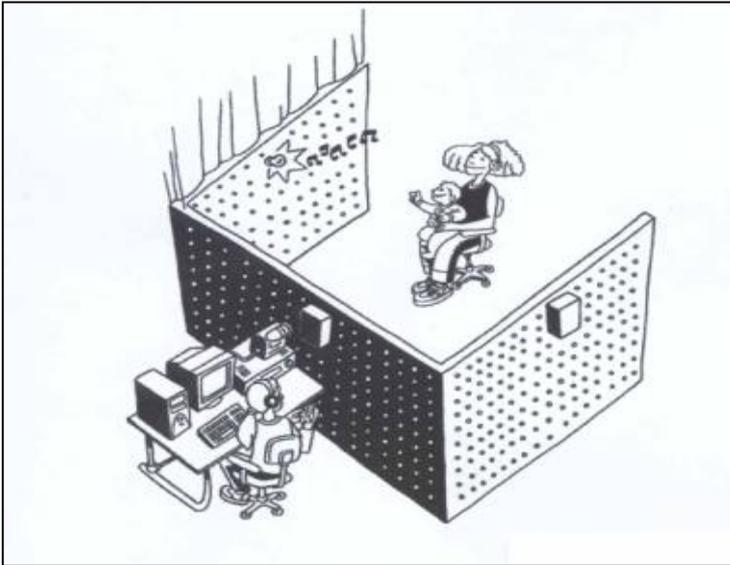
VOT PEL PEL JIC RUD TAM

- New words + old constructions

Gómez and Gerken 1999

After training, infants listened to two different sets of stimuli:

Condition 1

VOT PEL JIC

PEL TAM PEL JIC

PEL TAM JIC RUD TAM RUD

REL TAM JIC RUD TAM JIC

VOT PEL PEL JIC RUD TAM

- New words + old constructions

Condition 2

PEL TAM RUD RUD

VOT JIC RUD TAM JIC

VOT JIC RUD

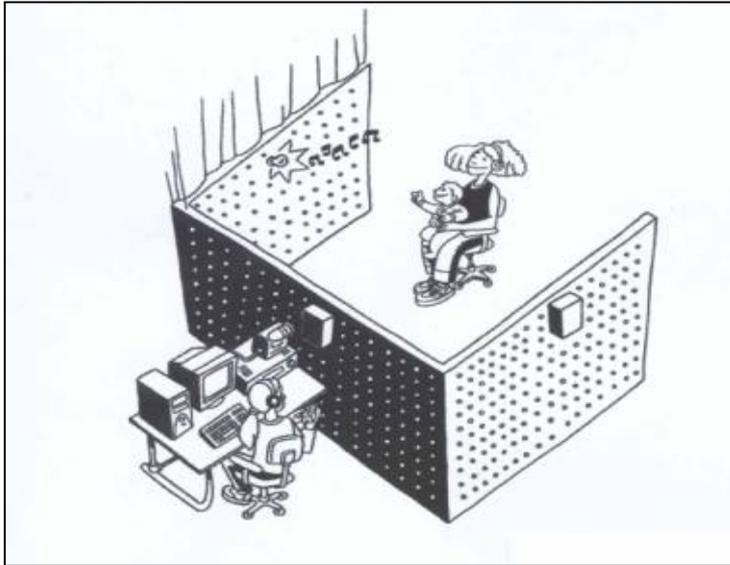VOT PEL JIC RUD TAM

PEL TAM PEL PEL PEL JIC
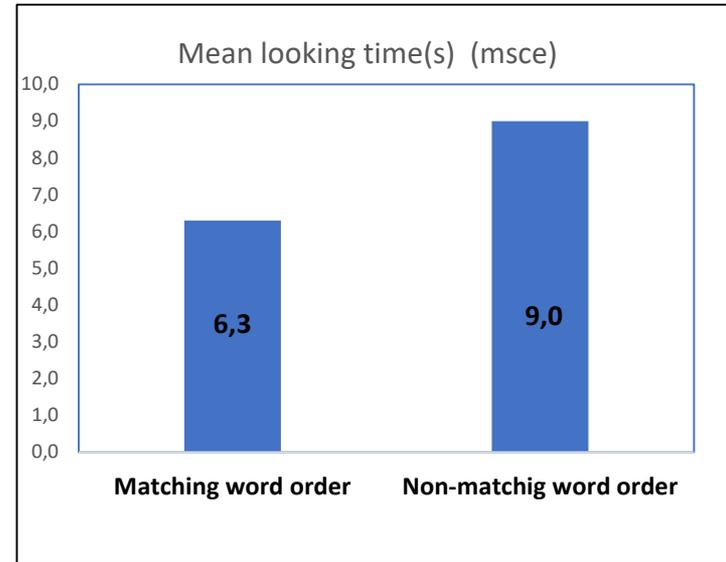
- New words + new constructions

Gómez and Gerken 1999

Listening preference procedure

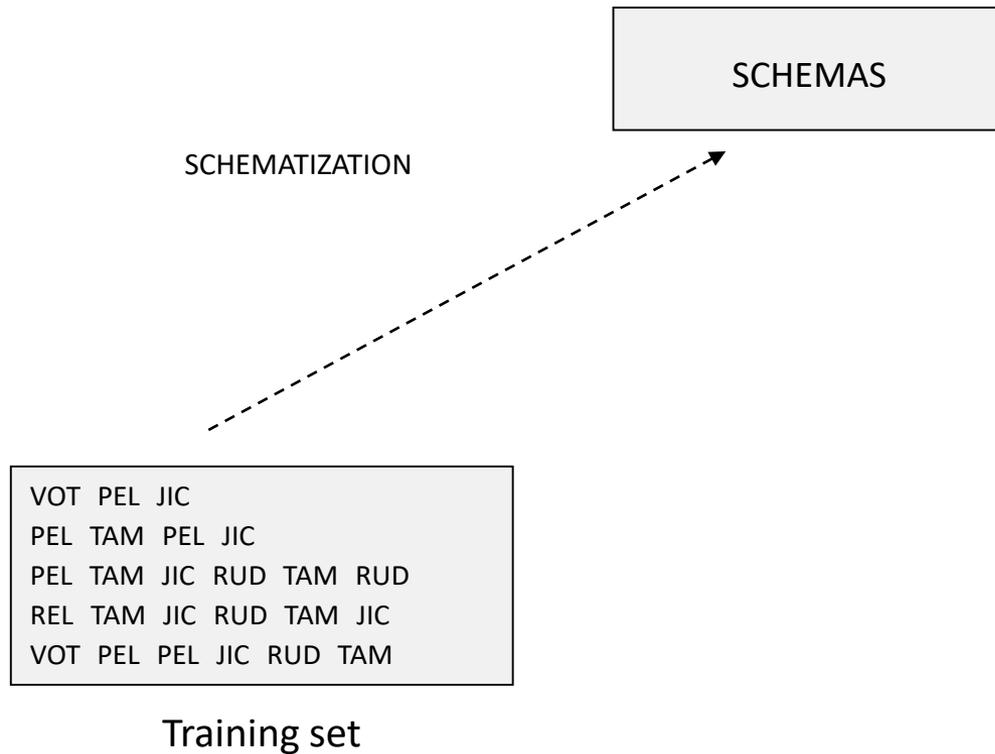# Gómez and Gerken 1999

Listening preference procedure

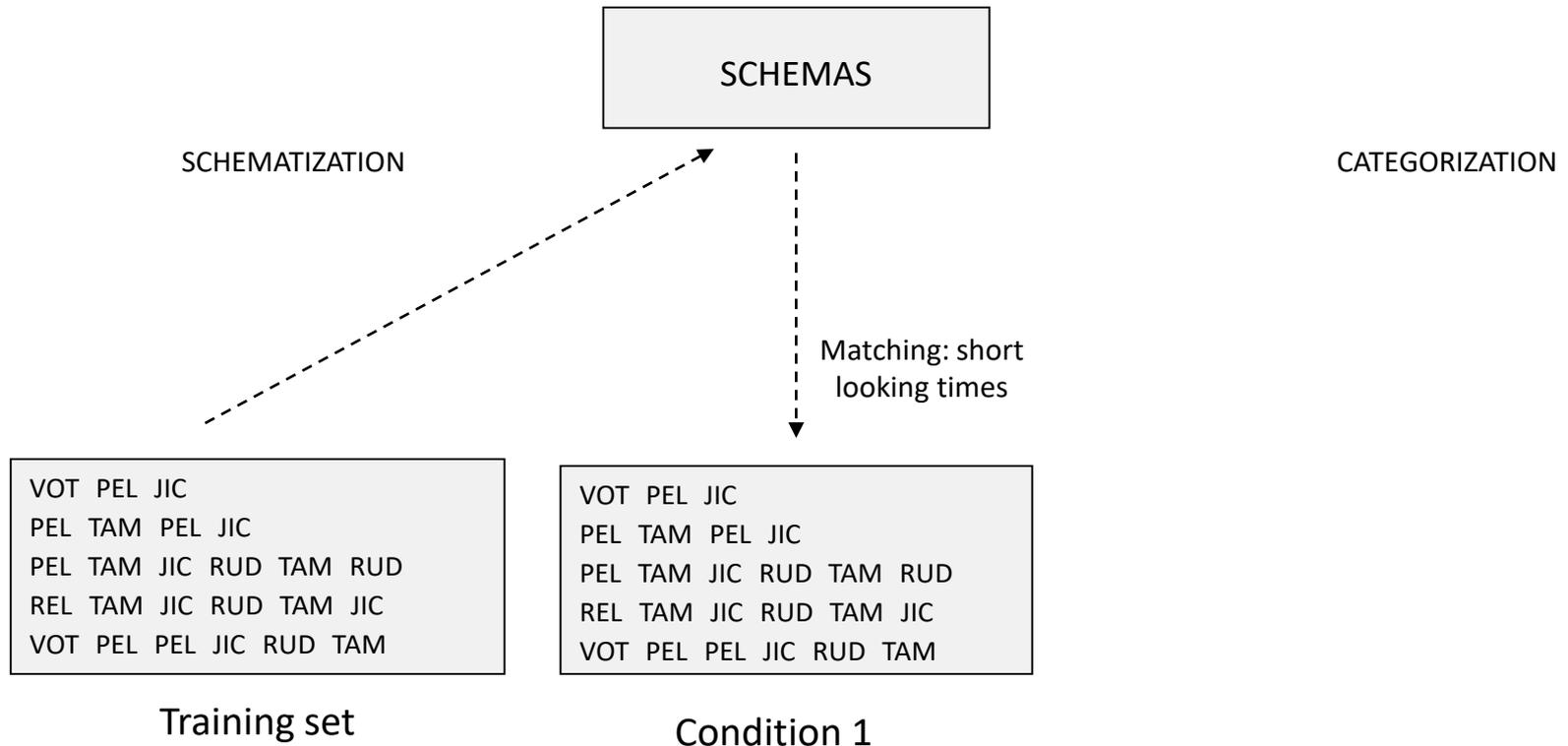Mean looking times

Gómez and Gerken 1999

```
VOT  PEL  JIC
PEL  TAM  PEL  JIC
PEL  TAM  JIC  RUD  TAM  RUD
REL  TAM  JIC  RUD  TAM  JIC
VOT  PEL  PEL  JIC  RUD  TAM
```
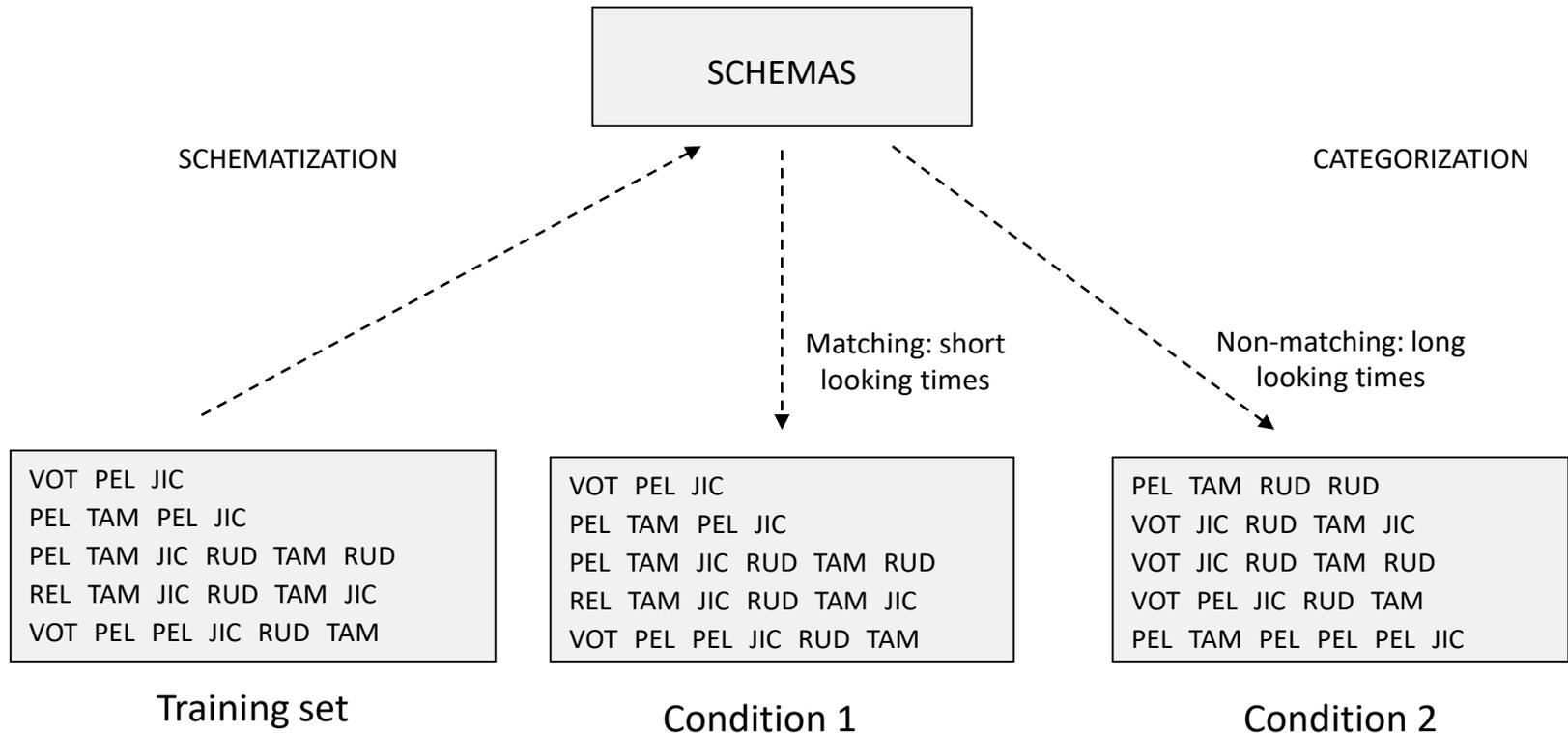
Training set

Gómez and Gerken 1999

SCHEMATIZATION

SCHEMAS

VOT PEL JIC
PEL TAM PEL JIC
PEL TAM JIC RUD TAM RUD
REL TAM JIC RUD TAM JIC
VOT PEL PEL JIC RUD TAM

Training set

Gómez and Gerken 1999

SCHEMAS

SCHEMATIZATION

CATEGORIZATION

Matching: short
looking times

VOT PEL JIC
PEL TAM PEL JIC
PEL TAM JIC RUD TAM RUD
REL TAM JIC RUD TAM JIC
VOT PEL PEL JIC RUD TAM

Training set

VOT PEL JIC
PEL TAM PEL JIC
PEL TAM JIC RUD TAM RUD
REL TAM JIC RUD TAM JIC
VOT PEL PEL JIC RUD TAM

Condition 1

Gómez and Gerken 1999

SCHEMATIZATION

SCHEMAS

CATEGORIZATION

Matching: short looking times

Non-matching: long looking times

Training set

```
VOT  PEL  JIC
PEL  TAM  PEL  JIC
PEL  TAM  JIC  RUD  TAM  RUD
REL  TAM  JIC  RUD  TAM  JIC
VOT  PEL  PEL  JIC  RUD  TAM
```

Condition 1

```
VOT  PEL  JIC
PEL  TAM  PEL  JIC
PEL  TAM  JIC  RUD  TAM  RUD
REL  TAM  JIC  RUD  TAM  JIC
VOT  PEL  PEL  JIC  RUD  TAM
```

Condition 2

```
PEL  TAM  RUD  RUD
VOT  JIC  RUD  TAM  JIC
VOT  JIC  RUD  TAM  RUD
VOT  PEL  JIC  RUD  TAM
PEL  TAM  PEL  PEL  PEL  JIC
```

The ambient language

The ambient language

Chomsky (1981): The ambient language is "meagre and degenerated" (see also Pinker 1989, 1999 and many others).

The ambient language

Redington et al. (1998)

Corpus: CHILDES (2.5 million words)

1000 most frequent words in the ambient language

The ambient language

	Context w. 1 (X the ___ of X)
Target w. 1	210
Target w. 2	376
Target w. 3	0
Target w. 4	1
Etc.	

The ambient language

	Context w. 1 (X the __ of X)	Context w. 2 (at the __ is X)
Target w. 1	210	321
Target w. 2	376	917
Target w. 3	0	1
Target w. 4	1	4
Etc.		

The ambient language

	Context w. 1 (X the ___ of X)	Context w. 2 (at the ___ is X)	Context w. 3 (X has ___ him X)
Target w. 1	210	321	2
Target w. 2	376	917	1
Target w. 3	0	1	1078
Target w. 4	1	4	987
Etc.			

The ambient language

	Context w. 1 (X the __ of X)	Context w. 2 (at the __ is X)	Context w. 3 (X has __ him X)	Context w. 4 (X He __ in any)
Target w. 1	210	321	2	0
Target w. 2	376	917	1	5
Target w. 3	0	1	1078	1298
Target w. 4	1	4	987	1398
Etc.				

The ambient language

	Context w. 1 (X the __ of X)	Context w. 2 (at the __ is X)	Context w. 3 (X has __ him X)	Context w. 4 (X He __ in any)
Target w. 1 Target w. 2 Target w. 3 Target w. 4 Etc.	210 376 0 1	321 917 1 4	2 1 1078 987	0 5 1298 1398

Context vectors:
- Target word 1   210-321-2-0
- Target word 2   376-917-1-5
- Target word 3   0-1-1078-1298
- Target word 4   1-4-987-1398

The ambient language

LEXICAL GROUPS	CATEGORY
you, we can, will, can't, … (49)	PRO, (NEG) AUX
where, who, who's, he's, … (53)	WH PRO, PRO, AUX
see, want, ate, fell, lost, … (105)	V
had, goes, told, gets, … (62)	V
going, used, called, lying, … (50)	V, PTC
the, a, your, his, … (29)	DET, POSS DET
and, so, no, hm, Eve (91)	CONJ, INTER
Adam, Naomi, Abe, … (19)	NAME
in, on, under, with, … (53)	P
house, car, tree, cookie, … (317)	N
little, blue, six, other, sugar, … (92)	ADJ, NUM, N
John, Mary, … (10)	NAME

Construction learning

Pivot schemas

Statistical grammar learning provides strong evidence for schema extraction.

But children are conservative with their generalizations (Braine 1976).

Pivot word	**Find-it __**	**More __**	**__ get it**
Examples	Find it funny	More corn	Block get it
	Find it bird	More that	Bottle get it
	Find it chess	More cookie	Phone get it
	Find it bricks	More popsicle	Towel get it
	Find it Weezer	More jump	Dog get it
	Find it ball	More Peter water	Books get it

Braine (1976): "pivot constructions"

Tomasello (1992): "verb-island constructions"

Pivot schemas

Hebrew-speaking children (Braine 1976)

(1) Tire kos.   'see glass'   (2) Ten li.   'give me'
     Tiri rakevet.   'see train'   Ten li kova.   'give me hat'
     Tire kise.   'see chair'   Ten li mayim.   'give me water'
     Tire susim.   'see horses'   Ten li oto.   'give me car'

(3) Hine migdal.   'here tower'   (4) Efo buba?   'where doll'
     Hine sus.   'here horse'   Efo uga?   'where cake'
     Hine kova.   'here hat'   Efo Aba?   'where daddy'
     Hine buba.   'here doll'   Efo sus?   'where horse'

Older children

As children get older they also generalize across verbs and use them across constructions:

(1)   He will **be died**

(2)   I don't like **being falled down** on.

(3)   Kendall **fall** that toy.

(4)   Don't **giggle** me.

Older children

As children get older they also generalize across verbs and use them across constructions:

(1) He will be died

(2) I don't like being falled down on.

(3) Kendall fall that toy.

(4) Don't giggle me.

Fully-schematic constructions

Verb-island constructions

Lexical strings
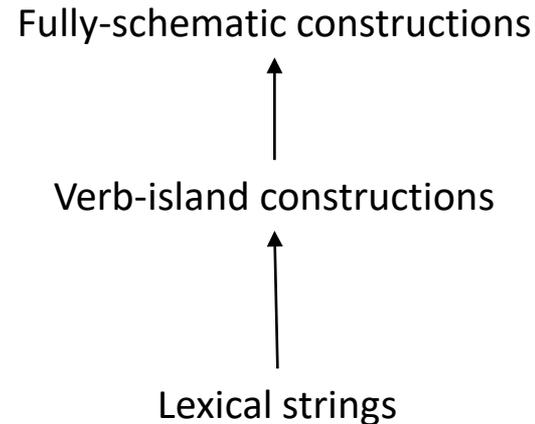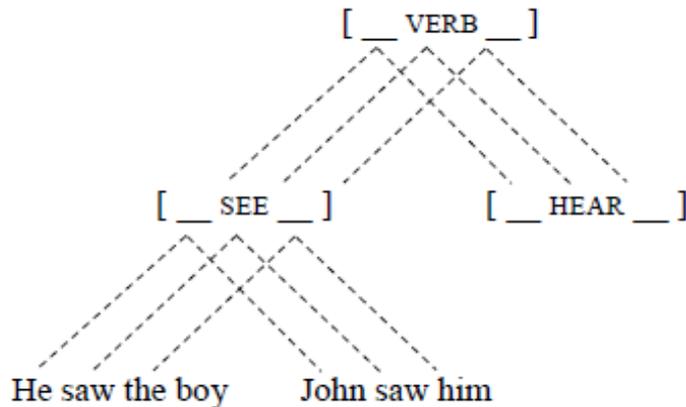
Language change and evolution

Change and evolution

The schemas children learn are implicit in the ambient language.

But where do these schemas come from?

Language change typically involves the extension or modification of existing schemas rather than the creation of entirely new ones.

Secondary modal verbs

Krug (2000): secondary modal verbs

going to, want to, have to, got to, try to, need to, suppose to ….

All of these verbs …

- take to-infinitives
- have a modal meaning
- often fuse (*want to -> wanna*)

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

Secondary modal verbs

But they originate from different source constructions.

Source constructions
***is going** to* INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

PROGRESSIVE

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

PROGRESSIVE

SIMPLE PRESENT

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

PROGRESSIVE

SIMPLE PRESENT

PASSIVE

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

TARGET CONSTRUCTIONS
gonna INFINITIVE
wanna INFINITIVE
hafta INFINITIVE
gotta INFINITIVE
tryto INFINITIVE
needto INFINITIVE
supposedto INFINITIVE

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

TARGET CONSTRUCTIONS
gonna INFINITIVE
wanna INFINITIVE
hafta INFINITIVE
gotta INFINITIVE
tryto INFINITIVE
needto INFINITIVE
supposedto INFINITIVE

- The grammatical differences of the source constructions disappear.

Secondary modal verbs

But they originate from different source constructions.

SOURCE CONSTRUCTIONS
is going to INFINITIVE
want to INFINITIVE
have to INFINITIVE
got to INFINITIVE
try to INFINITIVE
need to INFINITIVE
is supposed to INFINITIVE

TARGET CONSTRUCTIONS
gonna INFINITIVE
wanna INFINITIVE
hafta INFINITIVE
gotta INFINITIVE
tryto INFINITIVE
needto INFINITIVE
supposedto INFINITIVE
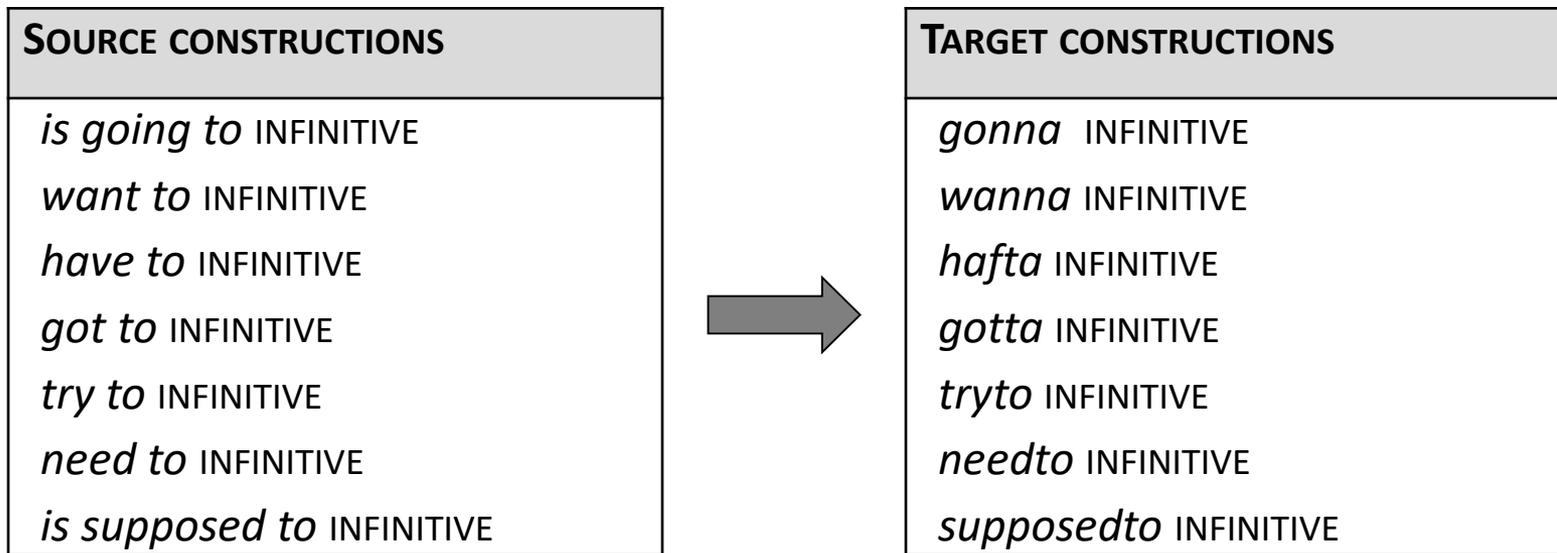
- ▪ The grammatical differences of the source constructions disappear.
- • The various forms converged on a phonetic template: /CVCə/.

Secondary modal verbs

NP   /CVCə/_{AUX}   INF   (NP)

NP wanna INF (NP)

NP gonna INF (NP)

NP gatta INF (NP)

Secondary modal verbs
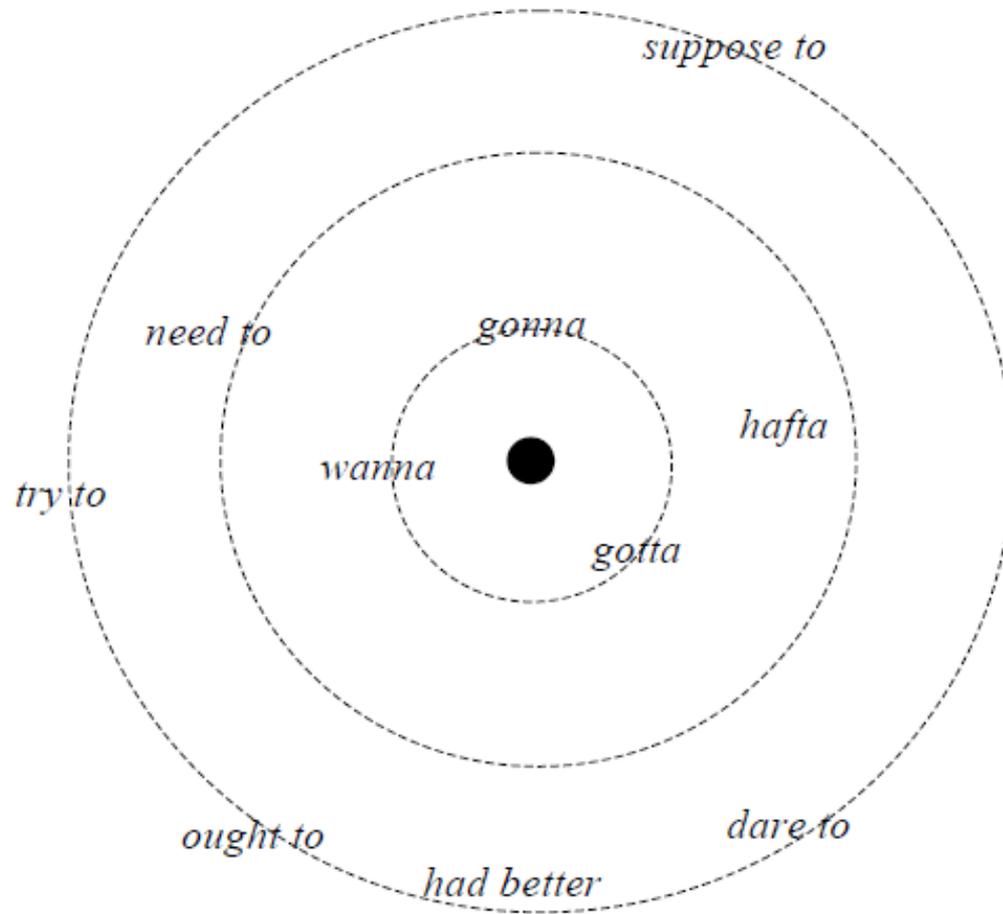
Sequential relations

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- Linear order is influenced by a wide range of cognitive processes, but the strength of sequential relations is determined by automatization.

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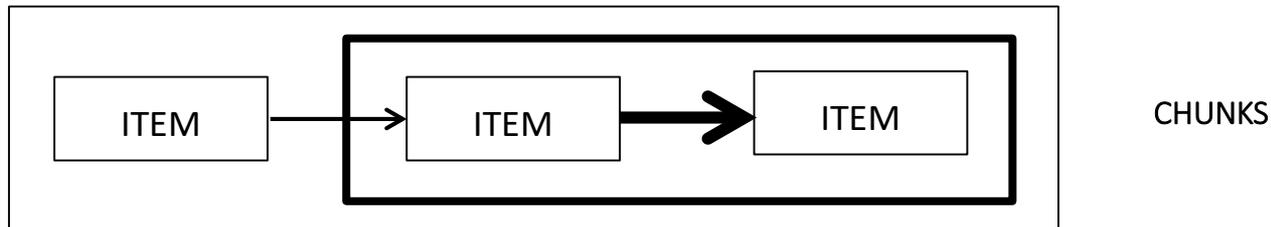
- Sequential relations are **asymmetrical**: they have an inherent forward orientation -> See current research on "linguistic predictions" (Altmann and Kamide 1999; Kamide et al. 2003; Hale 2008).

Lexical and schematic chunks
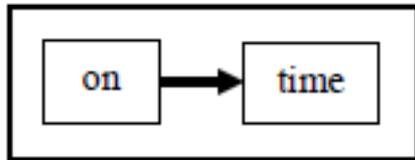
Lexical chunk
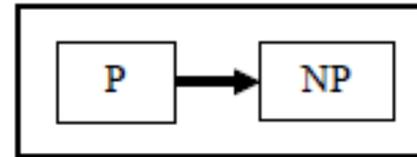
Schematic chunk

- Natural language abounds with lexical chunks, which often develop idiosyncratic properties (Wray 2002; Matthew and Bannard 2008; Arnon and Snider 2010).
- Since schematic chunks are derived from lexical chunks, they usually have the same internal structures.
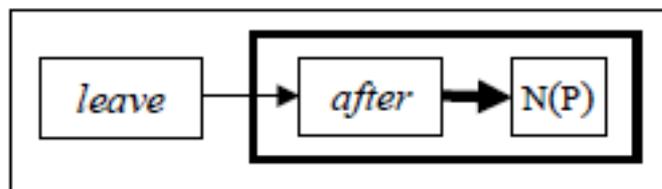
FREE COMBINATIONS
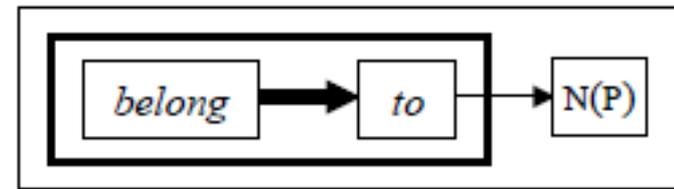
PHRASAL VERBS

Words

Words

The best example of a lexical chunk is the unit 'word'.

> The word is the unit par excellence of traditional grammatical theory. It is the basis of the distinction which is frequently drawn between morphology and syntax and it is the principal unit of lexicography …. [Lyons 1968: 194]

The unit word is **not** primitive and basic, but fluid and derived.

Words

(1) Lao (Enfield 2007)

khon2 thii1 laaw2 lèèn1 siø bòø paj3

person REL 3SG run IRR NEG go

'The person who ran will not be going.'

(2) Mohawk (Mithun 1984)

t-v-hshakoti-ya't-ayest-áhsi-'.

DU-will-they/them-body-mix-REVERSE-PUNC

'They will pick them out

In the typological literature, words are usually defined by a combination of syntactic and phonological features (Haspelmath 2011; Schiering et al. 2011)

Haspelmath (2011): There is no universal concept of wordhood.

➤ Even at the level of individual languages, the unit word is **not** a uniform concept (**word > clitic > affix**).

Morphological gradients

Morphological (de)composition

Toolkit approach: Network approach:

car + s = car-s

readable

washable

unbelievable

believe

unattractive

unwarranted
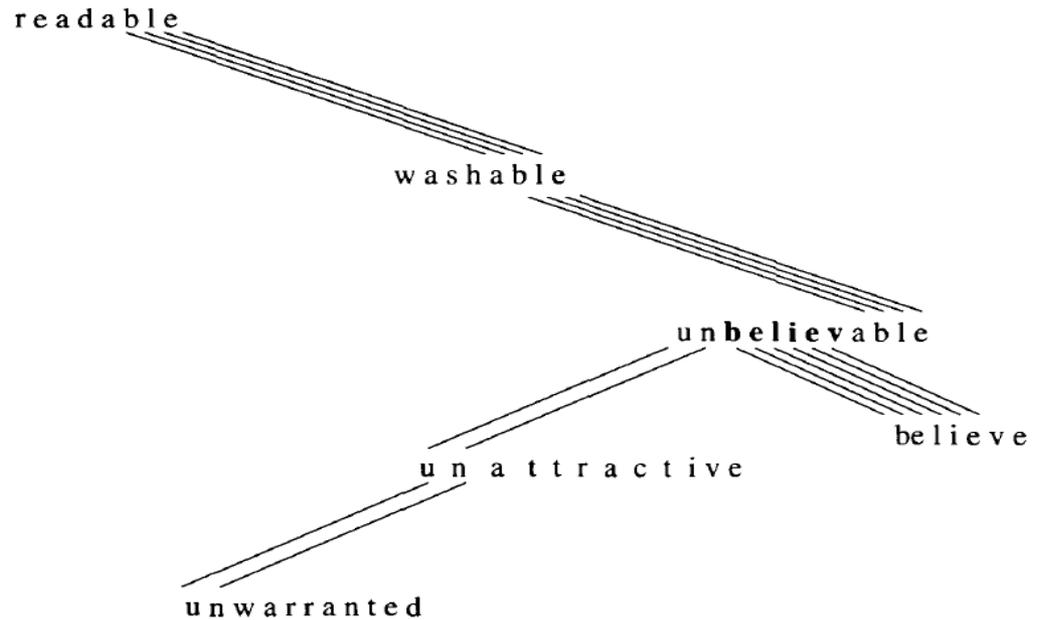
Bybee 1995
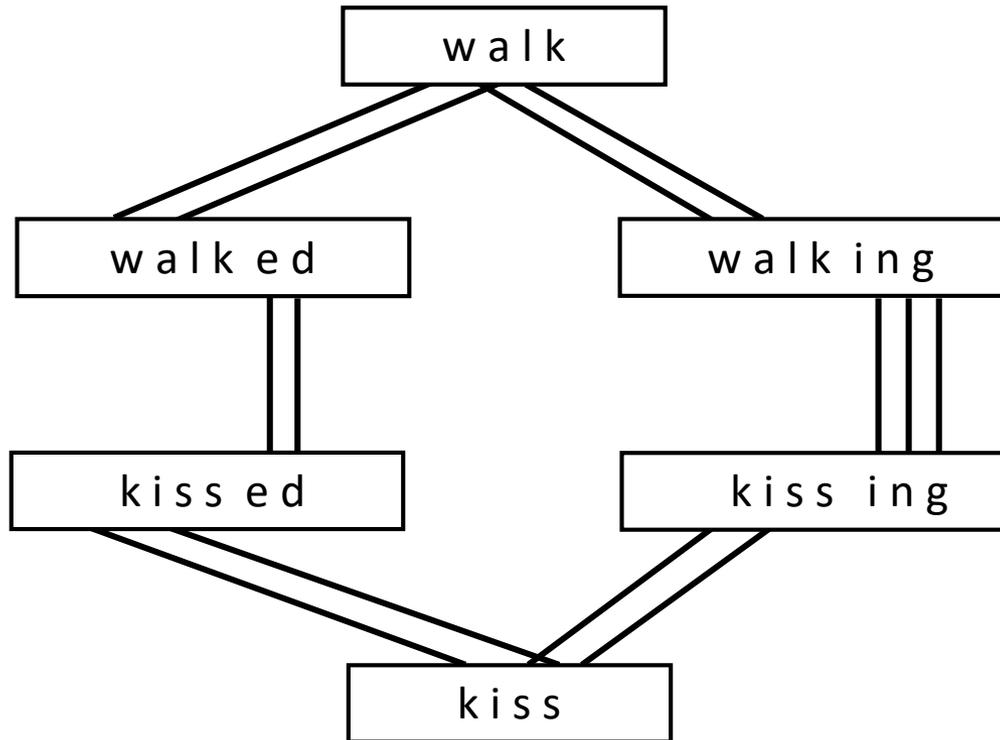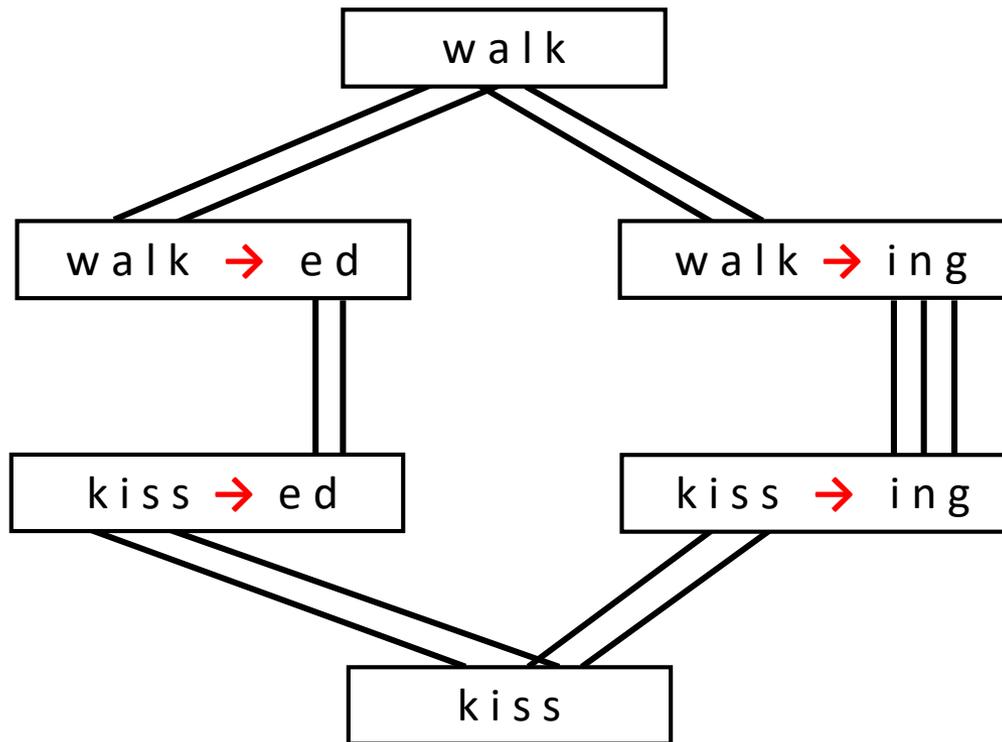
Words

Words

Words

Morphological structure is determined by the interaction between sequential and lexical relations.

- Sequential links are determined by automatization
- Lexical links are created by categorization or analogy

On this account, every lexeme has a unique representation that is determined by language users' experience with particular words.

Hay 2001

(1) a. refurbish
       b. rekindle

	Frequency of complex form	Frequency of base
refurbish - furbish	33	1
rekindle - kindle	22	41

Hypothesis: If the structure of complex word forms is determined by the interaction between lexical and sequential associations, words such as *refurbish* are not so easily decomposable than words such as *rekindle*.

Hay 2001

List A	complex freq	base freq	List B	complex freq	base freq
PREFIXED WORDS			PREFIXED WORDS		
re-furbish	33	1	re-kindle	22	41
in-animate	34	4	in-accurate	53	377
un-canny	89	20	un-common	114	3376
...	...	...	...	...	...
SUFFIXED WORDS			SUFFIXED WORDS		
slim-y	61	35	cream-y	74	540
hap-less	22	13	top-less	27	3089
respir-ation	39	4	ador-ation	49	218
...	...	...	...	...	...

Which word is **less** complex: *refurbish* or *rekindle*?
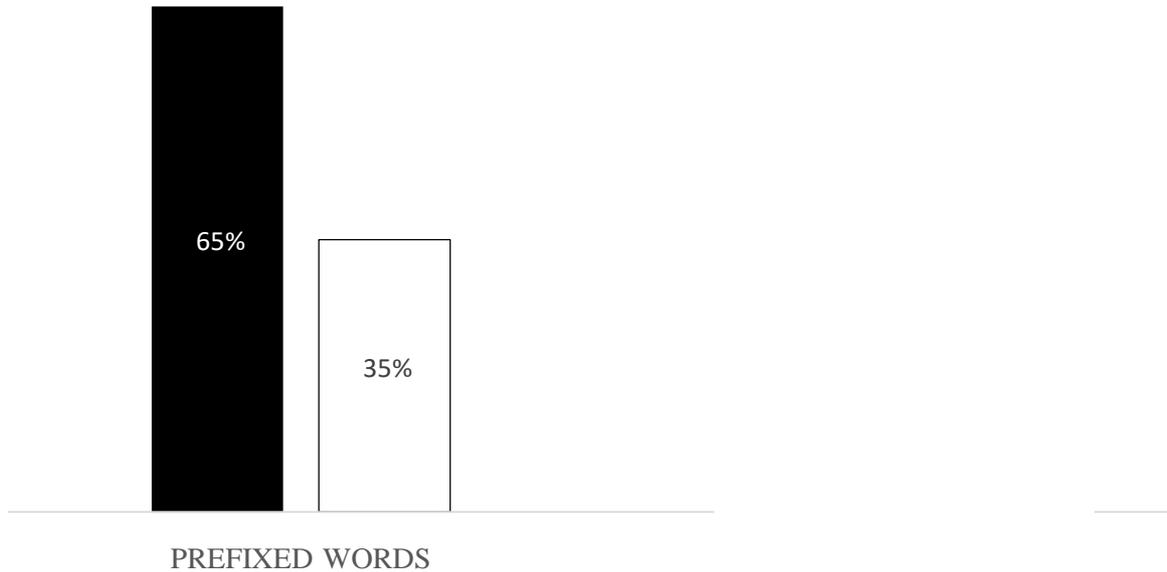
Hay 2001

65%

35%

PREFIXED WORDS

■ Word of List A is considered less complex than its counterpart on List B
□ Word of List B is considered less complex than its counterpart on List A

Hay 2001

PREFIXED WORDS   SUFFIXED WORDS
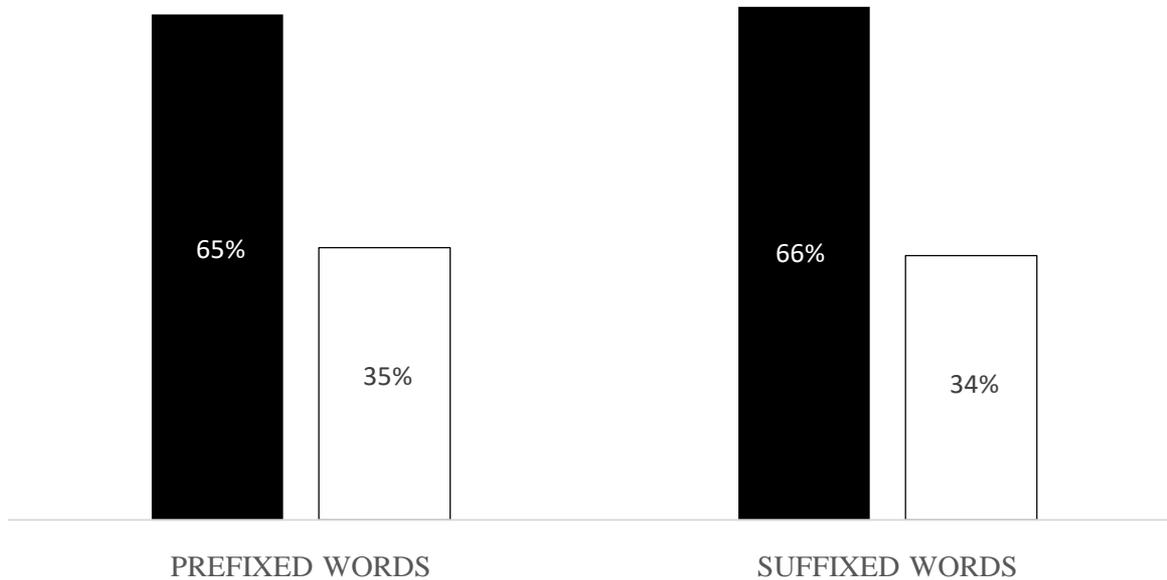
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Hay 2001

Lexical autonomy

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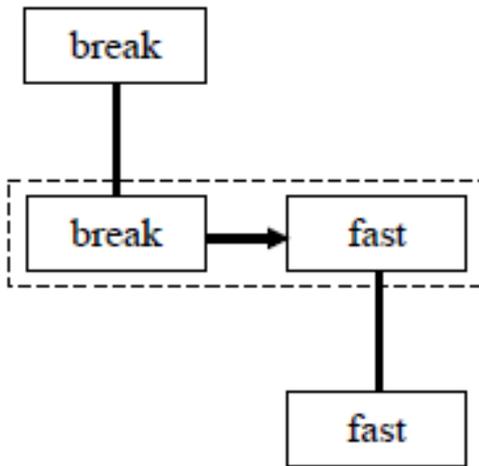
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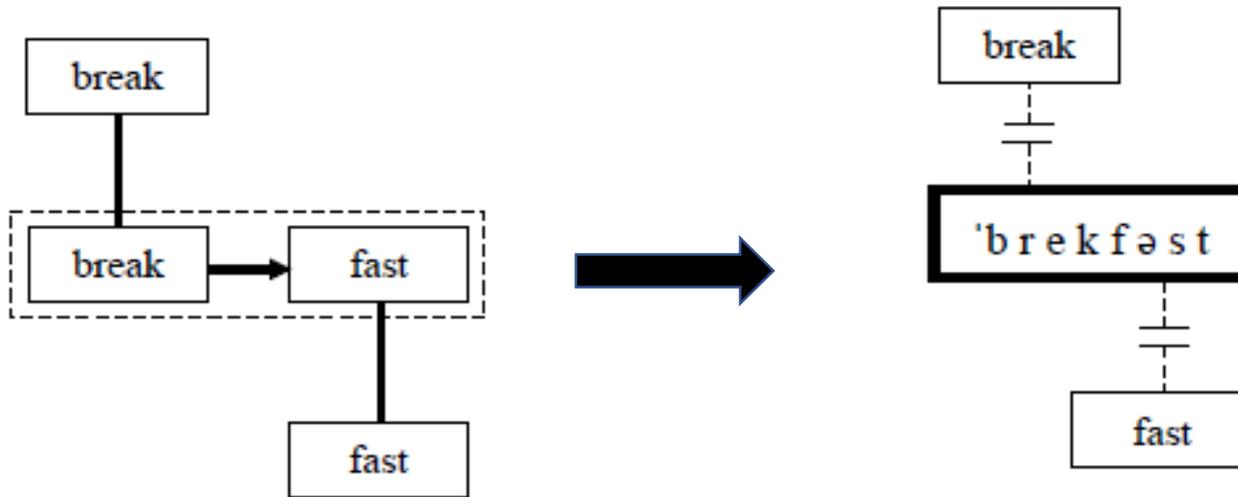
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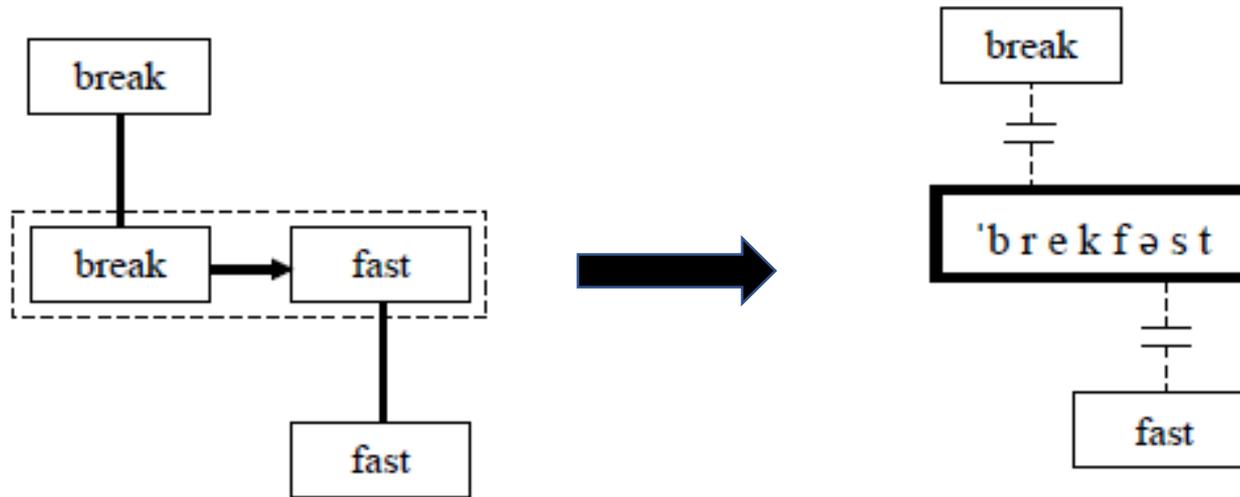
Other examples:

(1)	today	<	to dæge
(2)	holiday	<	holy day 'religious feast'
(3)	handicap	<	hand in the cap
(4)	because	<	by cause

The suffixing preference

The suffixing preference

Greenberg (1966): Suffixes are cross-linguistically more frequent than prefixes (see also Dryer 2005)

Where do (inflectional) suffixes come from?

Bybee (1990):   Free GRAMs that follow their lexical hosts are more likely to develop into affixes than free GRAMs that precede their hosts.

The suffixing preference
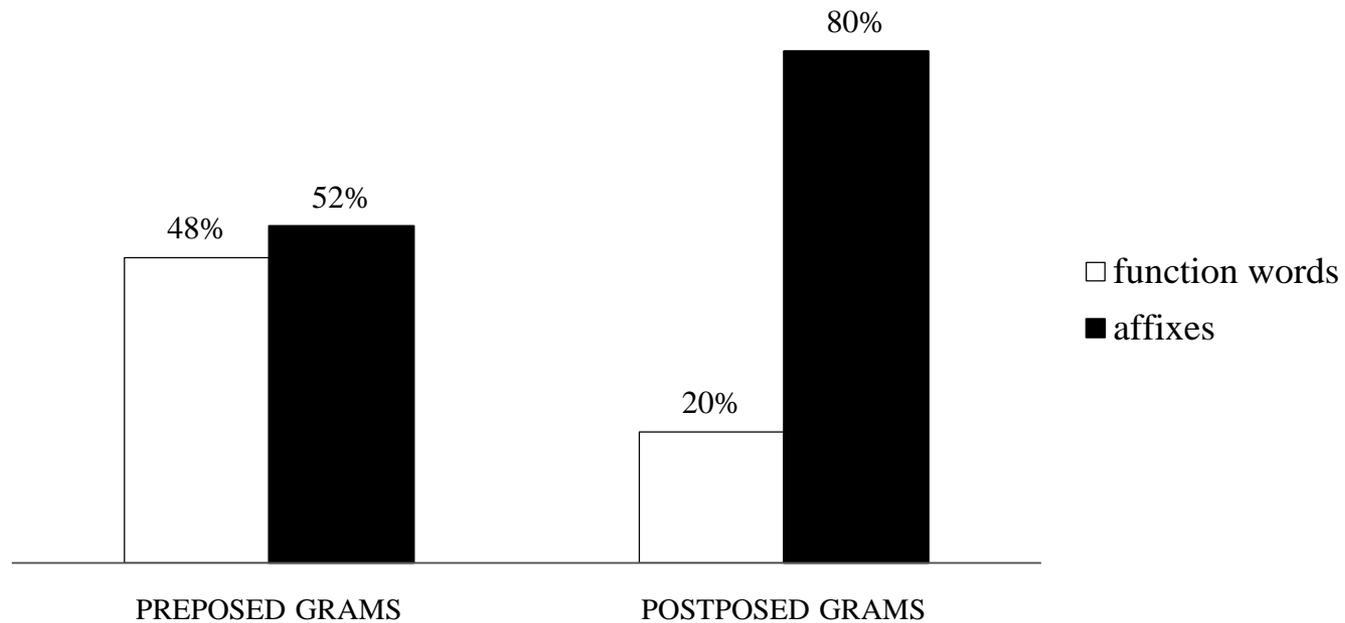
Based on data from Bybee et al. (1990)

The suffixing preference

Why are postposed GRAMs more like to develop into affixes than preposed GRAMs?

Hypothesis: This can be explained by the orientation of sequential processing.

Hypothesis: The strength of these predictions varies with the order in which function words and content words are arranged.

The suffixing preference

Example: determiner + noun

  (1)   English
        the boy

the

The suffixing preference

Example: determiner + noun

(1)   English
      the boy

$$\text{the} \left\{ \begin{array}{c} \boxed{N_1} \\ \boxed{N_2} \\ \boxed{N_3} \\ \boxed{N_4} \\ \boxed{\ldots} \end{array} \right.$$
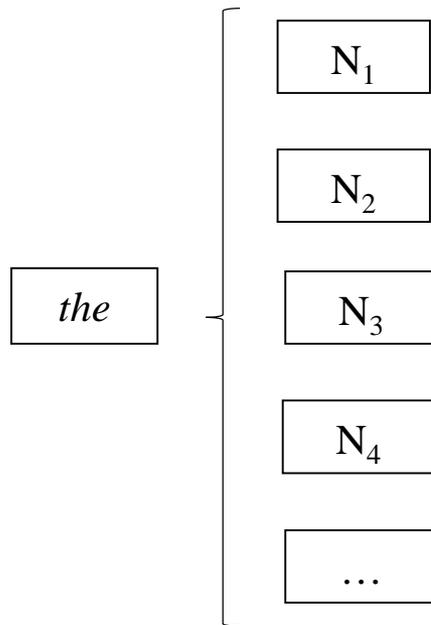
The suffixing preference

Example: determiner + noun

(1) English
  the boy

(2) Lakhota
  mathó **ki** 'bear the'

The suffixing preference

Example: determiner + noun

(1) English
the boy

```
        ┌ N₁ ┐
        │ N₂ │
the ────┤ N₃ │
        │ N₄ │
        └ … ┘
```

(2) Lakhota
mathó **ki** 'bear the'

```
        ┌ ki ┐
N ──────┤    │
        └ … ┘
```
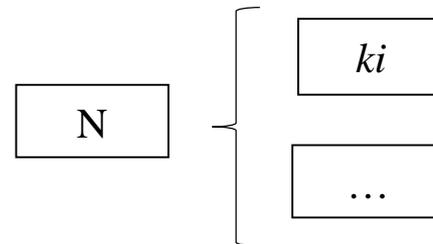
The suffixing preference

BNC: the (N= 3.004.338)
        boy (N= 19.915)
        the boy (N=5.162

$$P = \frac{\text{the boy}}{\text{the}} = \frac{5.162}{3.004.338} = 0.00017$$

Imagine a language with the same token frequncies in which *the* and *boy* occur in reverse order:

$$P = \frac{\text{boy the}}{\text{boy}} = \frac{5.162}{19.915} = 0.25709$$

The suffixing preference

If sequential processing involves an anticipatory component, then …

| GRAM | - - - - -> | CONTENT |

| CONTENT | ===> | GRAM |
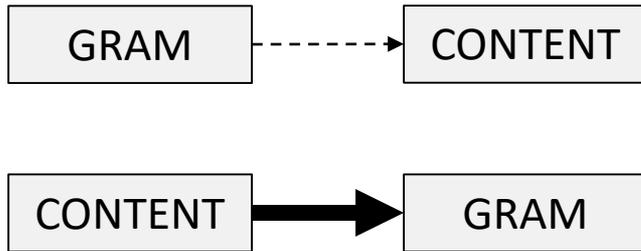
See also Himmelmann (2014)

Symbolic relations

Symbolic relations

Traditionally, word meanings are defined by reference; but in cognitive linguists meaning is conceptualization.

Words are cues that provide access to a network (Collins and Loftus 1975; Anderson 1983; Dell 1986)

Activation spreading
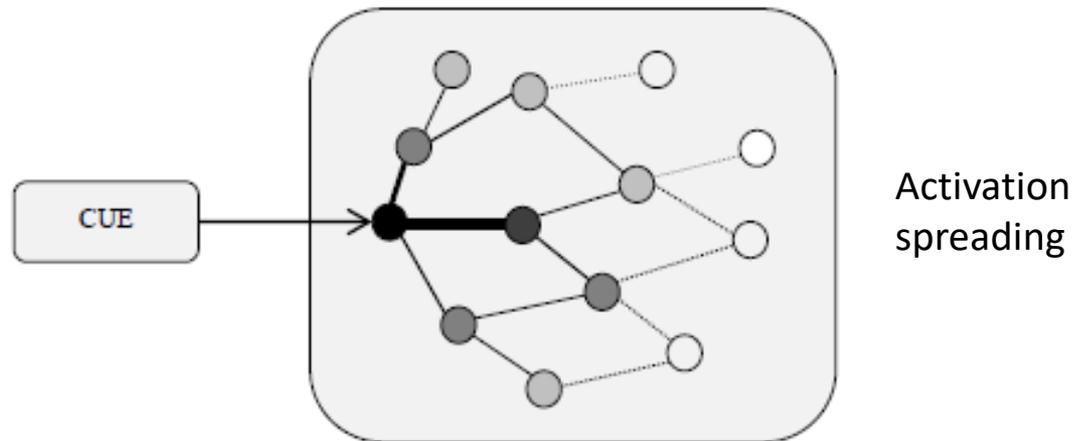
Evidence from priming

Symbolic relations

The meaning of 'roof':

Symbolic relations

The meaning of 'roof':

[rʊf]

Symbolic relations
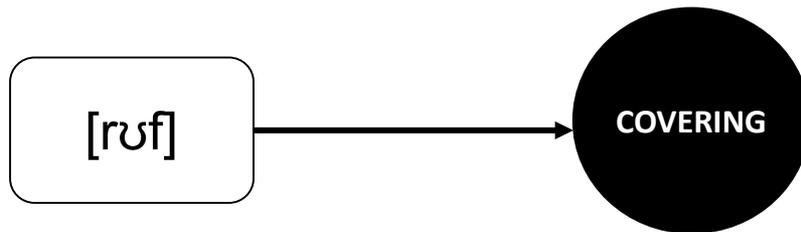
The meaning of 'roof':

Symbolic relations

The meaning of 'roof':

FIGURE   **GROUND**

[rʊf] → COVERING ---- BUILDING

Symbolic relations

The meaning of 'roof':

FIGURE   **GROUND**

[rʊf] → **COVERING** ---- **BUILDING**
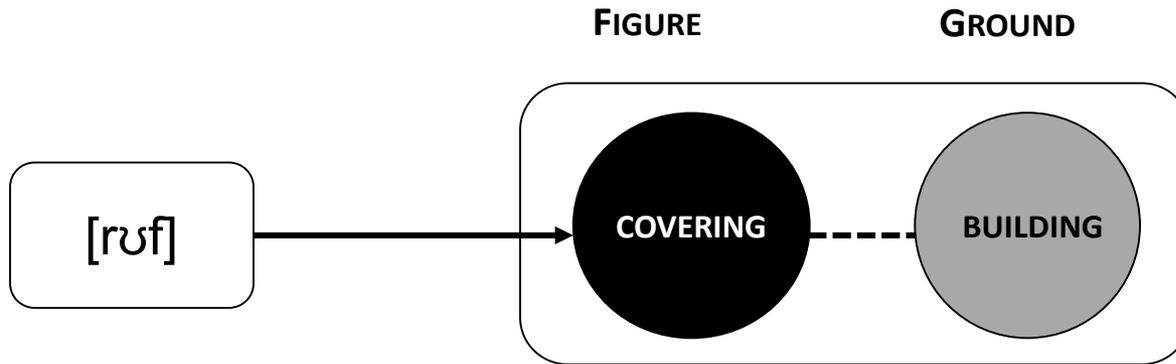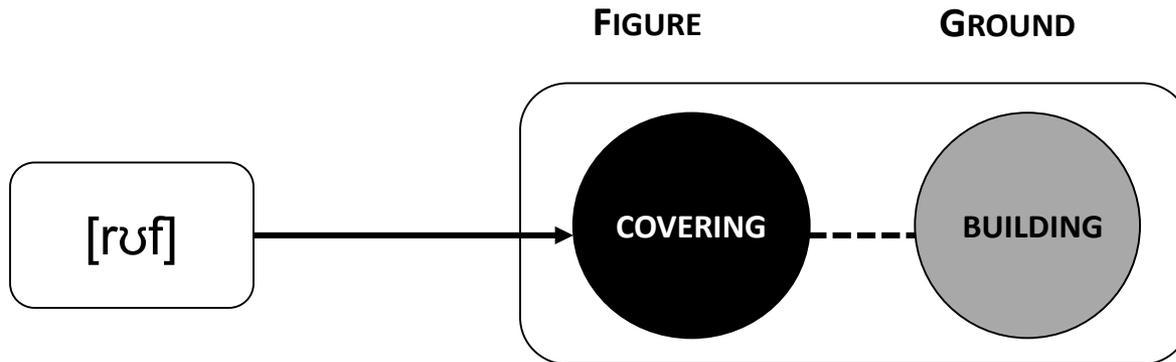
Related concepts:
- Weather, rain, snow
- Chimney, tile
- Shelter, cover

Symbolic relations

Frame

[rʊf] → **COVERING** - - - - **BUILDING**

Symbolic relations

Frame

[rʊf] → COVERING - - - BUILDING

Domain
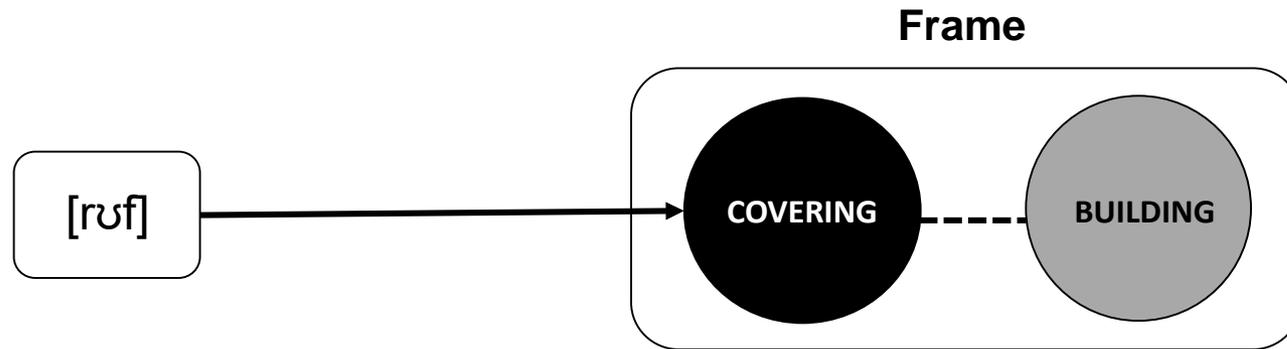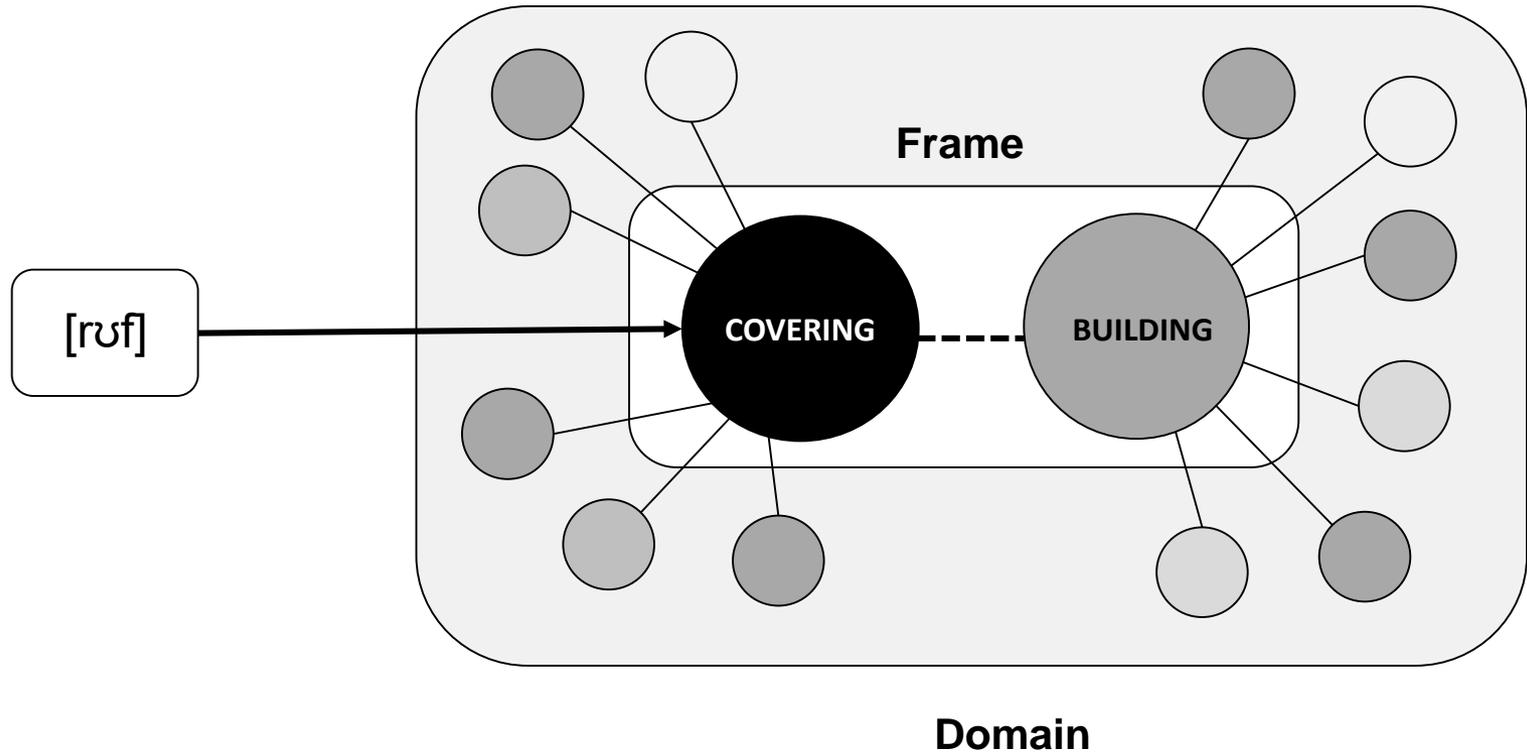
Symbolic relations

The meaning of 'summer':

- entails the three other seasons
- evokes a wide range of other concepts

➢ sunshine, vacation, swimming, fun, strawberries

Symbolic relations
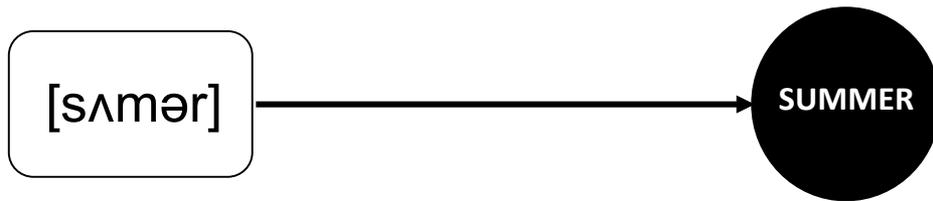
[sʌmər] → **SUMMER**

Symbolic relations
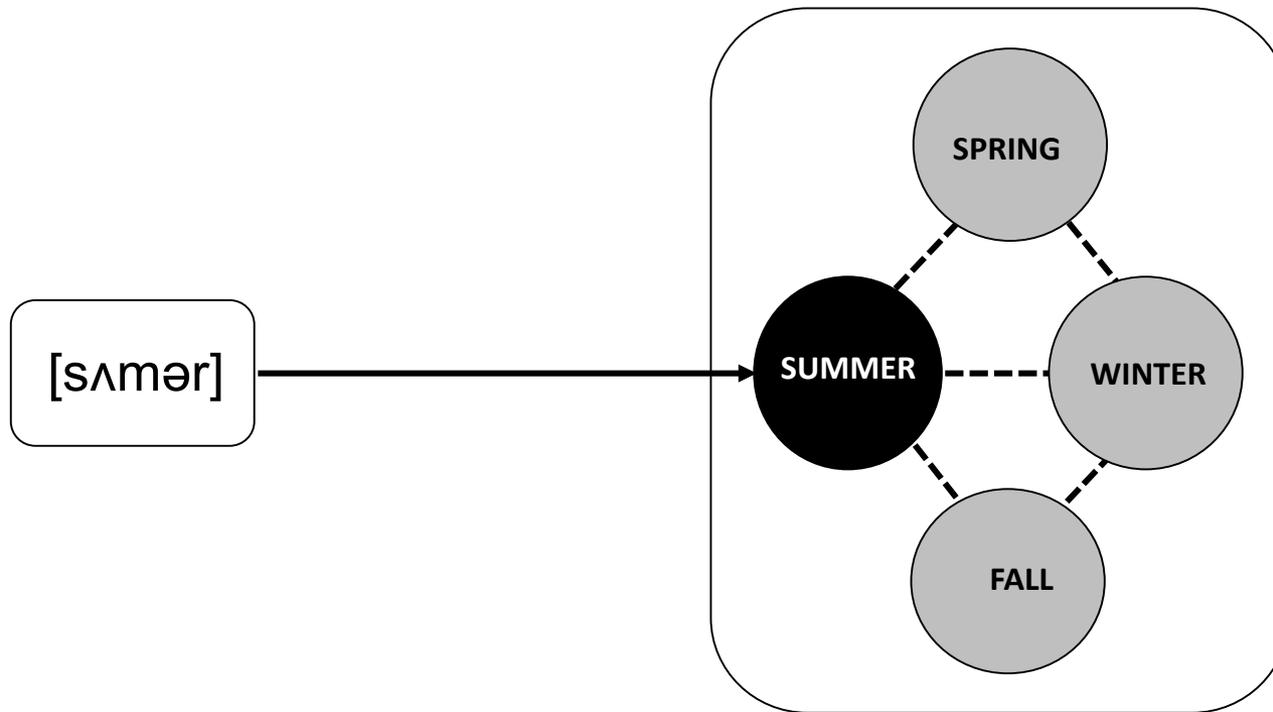
Symbolic relations
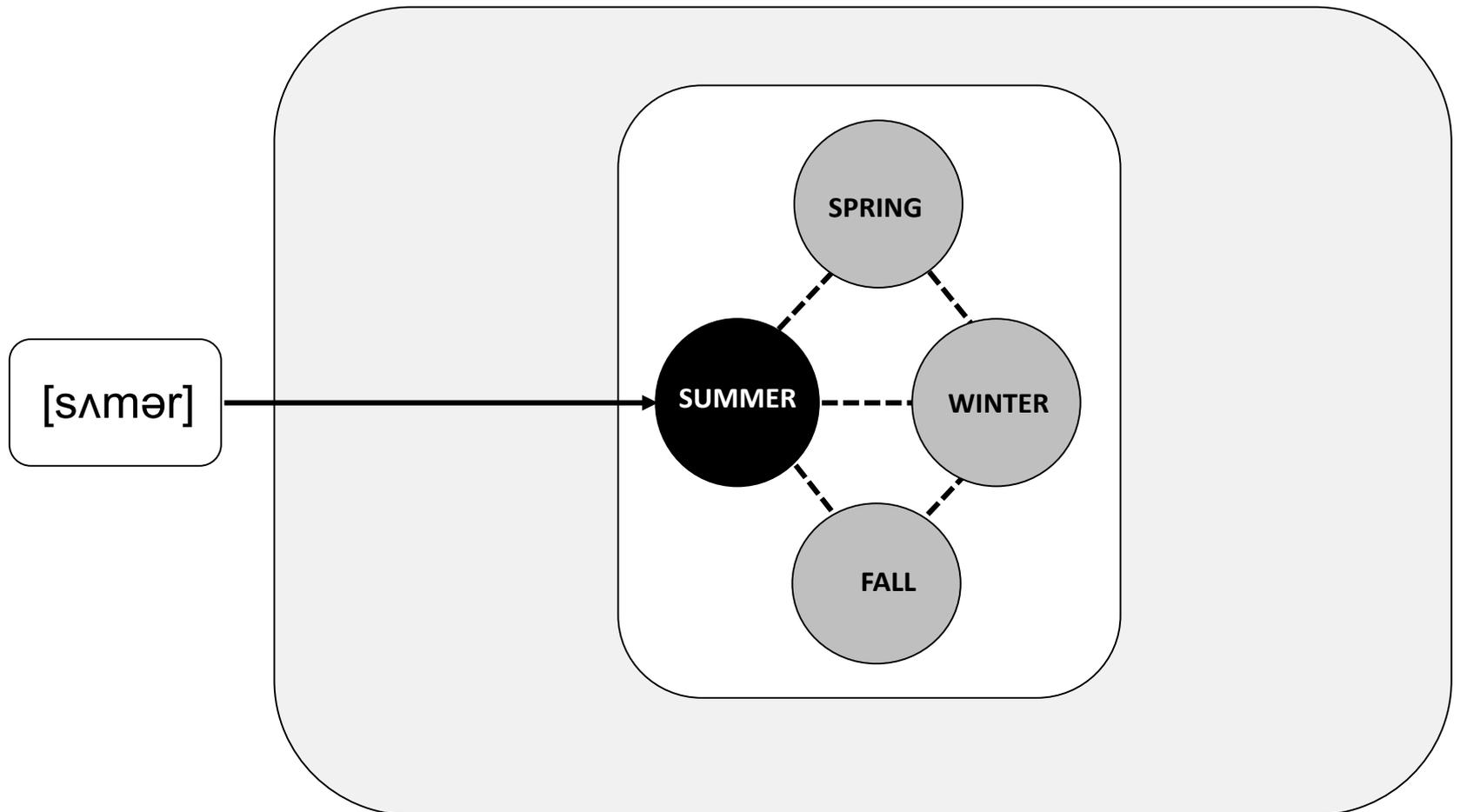
Symbolic relations
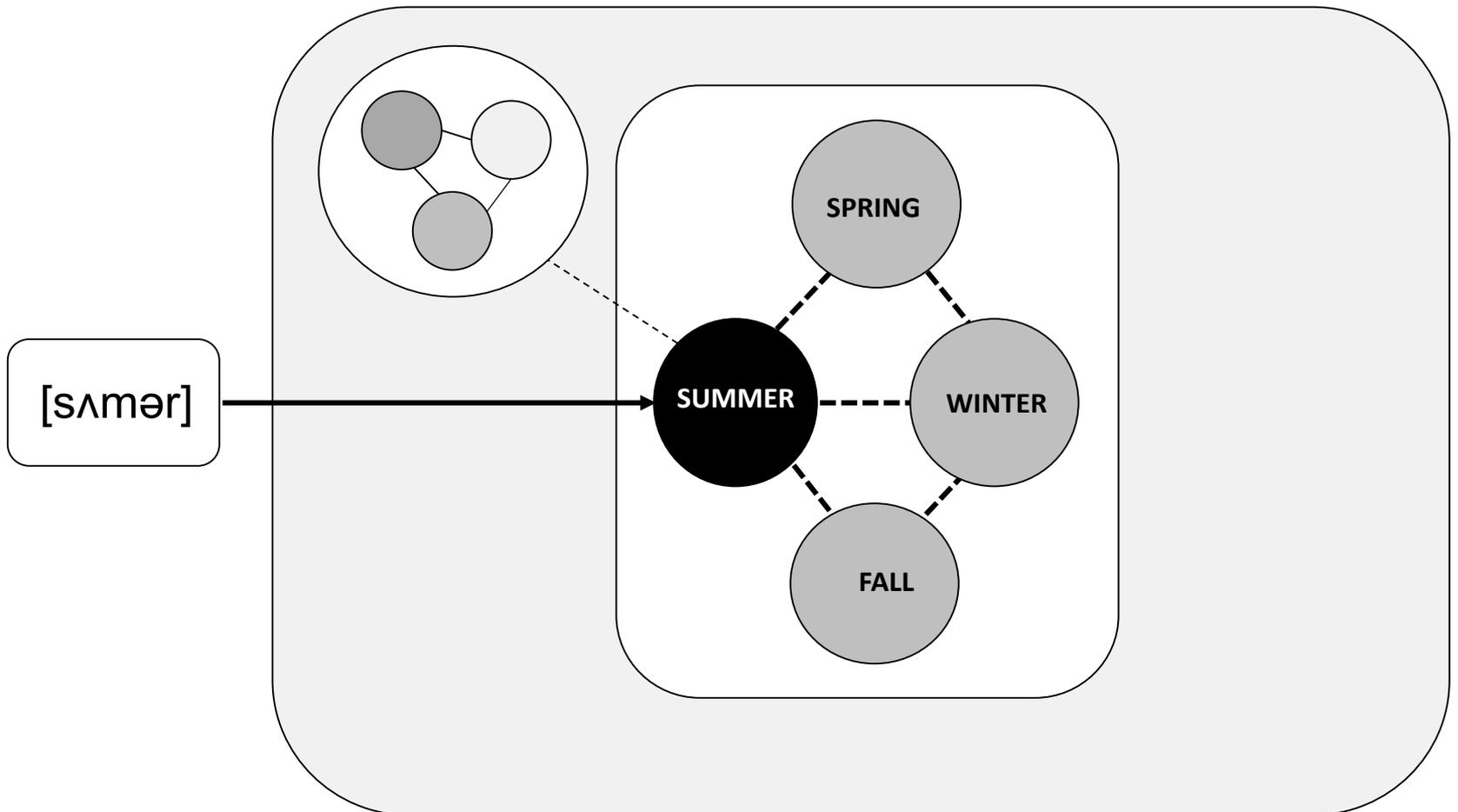
Symbolic relations
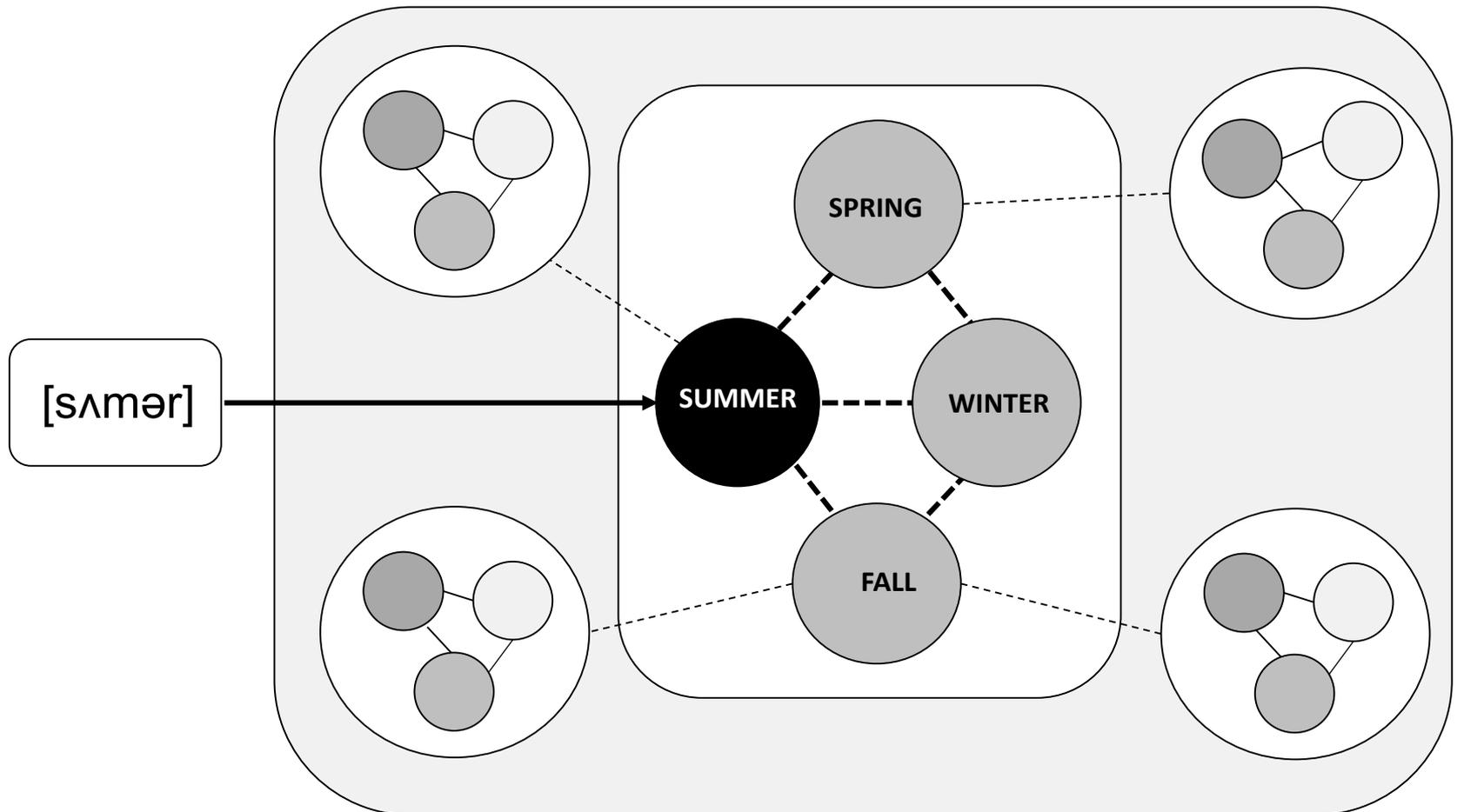
Symbolic relations

Frame semantics was developed by Charles Fillmore.

Frame semantics has been particularly useful to describe the meaning of verbs.

Verbs are relational expressions.

(1) John sent Mary a mail.

'Send' entails:
- Sender
- Receiver
- Theme

Symbolic relations
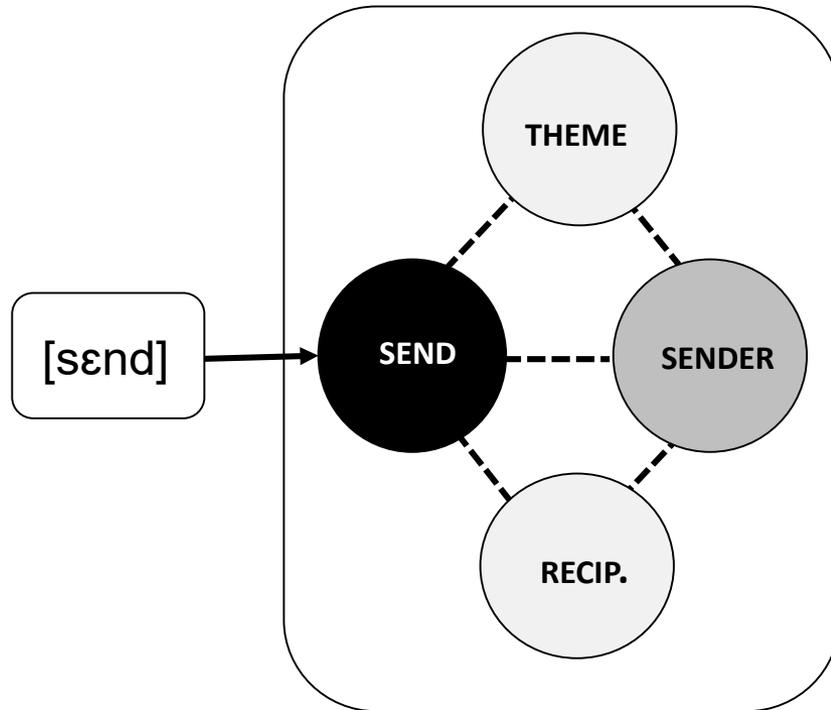
(1) John sent Mary a mail.

Symbolic relations
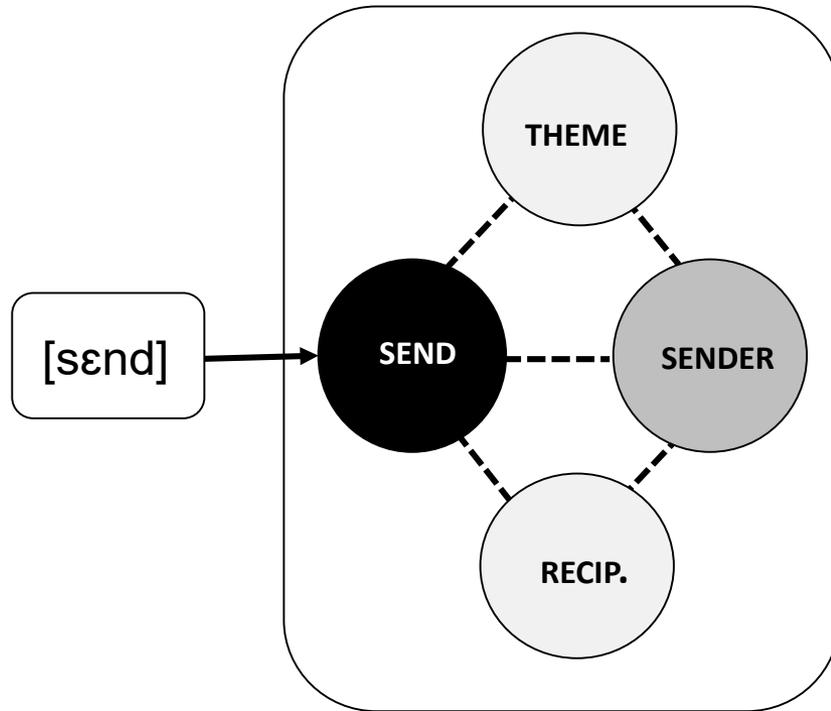
(1) John sent Mary a mail.

(2) Mary received a mail from John.

Symbolic relations
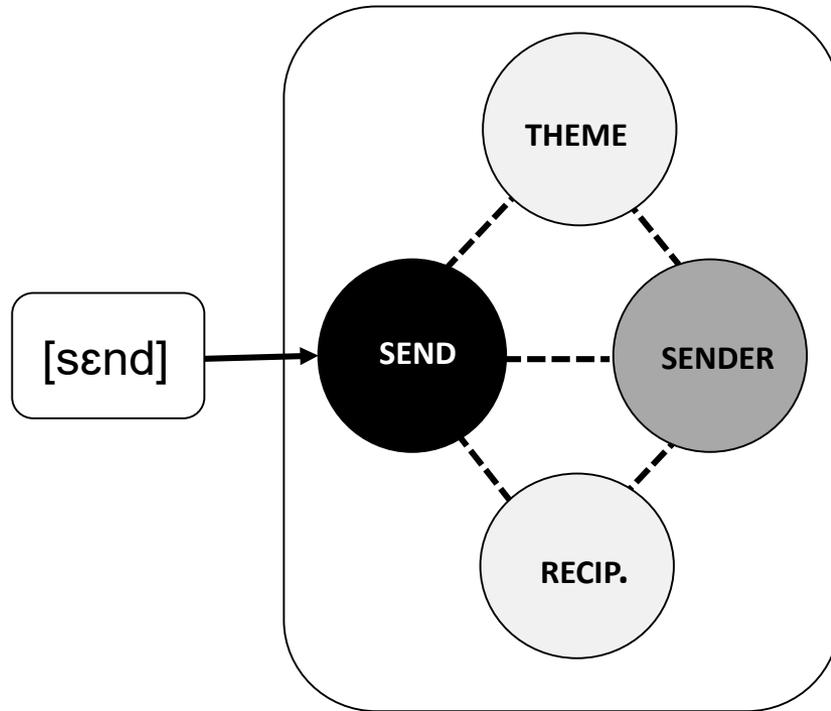
(1) John sent Mary a mail.
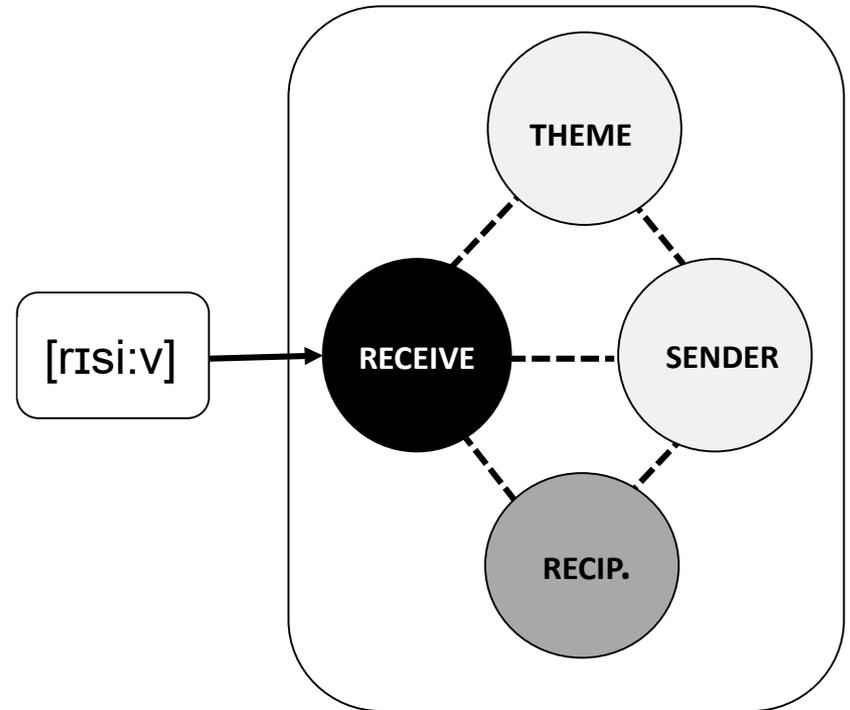
(2) Mary received a mail from John.

Conceptual integration

Conceptual integration

The networks that are evoked by individual lexemes need to be integrated into a coherent interpretation.

Conceptual integration
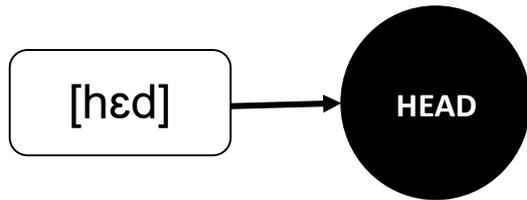
(1)   head of a person

Conceptual integration

(1)   head of a person

Conceptual integration
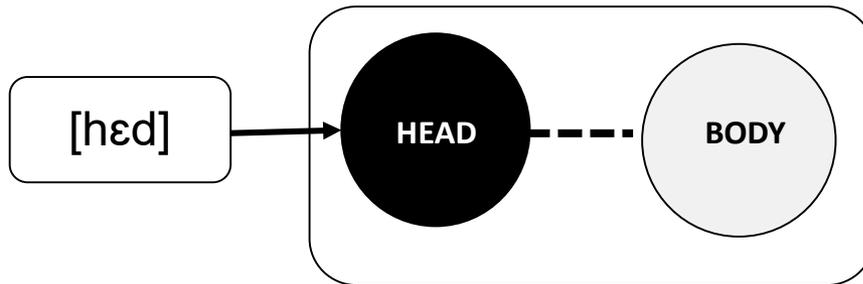
(1)   head of a person

Conceptual integration
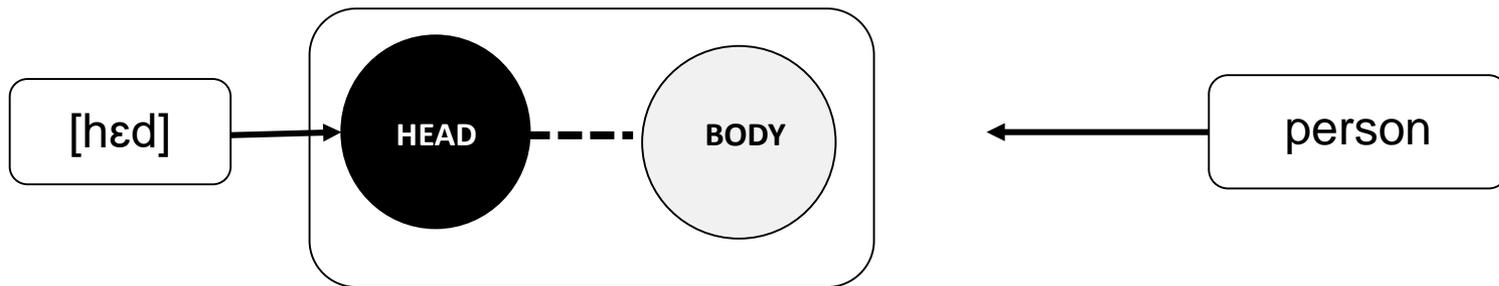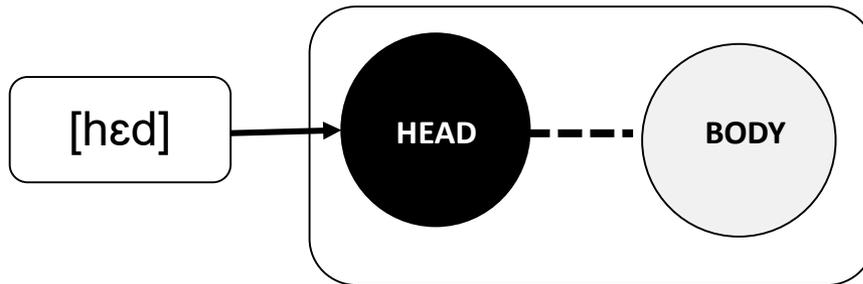
(1) head of a person

Conceptual integration

(1)   head of a person

(2)   head of a snake

Conceptual integration
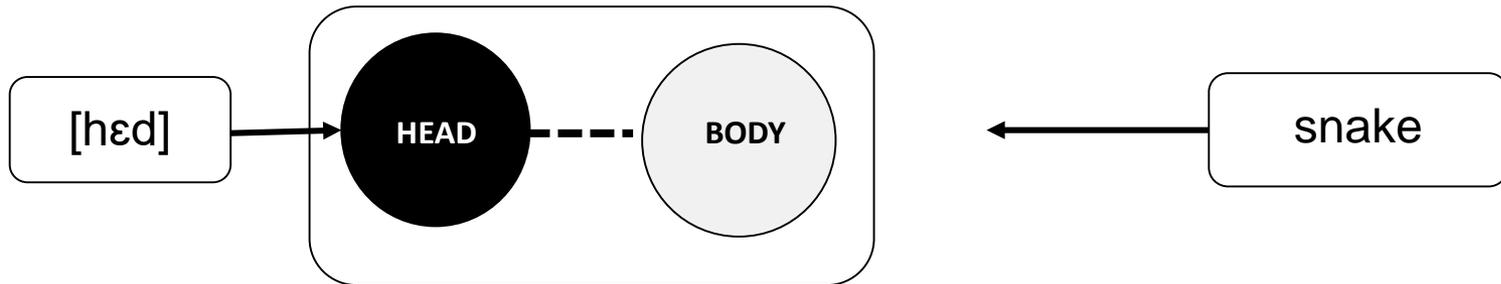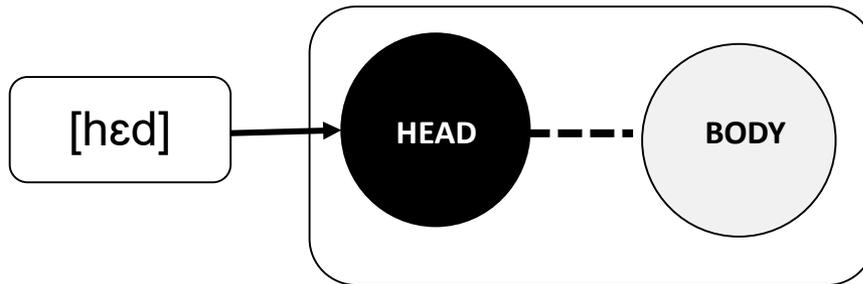
(1)   head of a person

(2)   head of a snake

[hɛd] → **HEAD** - - - **BODY** ← snake

Conceptual integration

(1)　　　head of a person

(2)　　　head of a snake

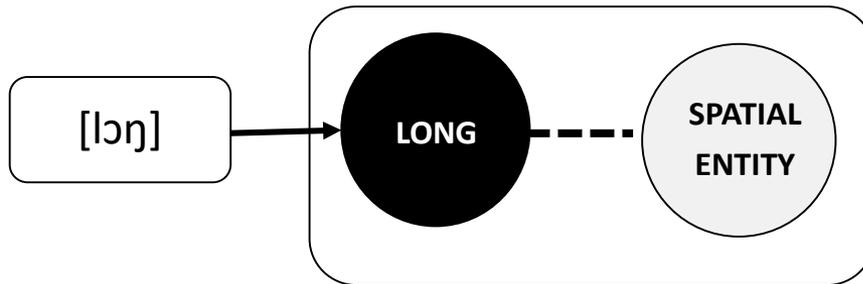(3)　　　head of department

Conceptual integration

(1)   head of a person

(2)   head of a snake

(3)   head of department
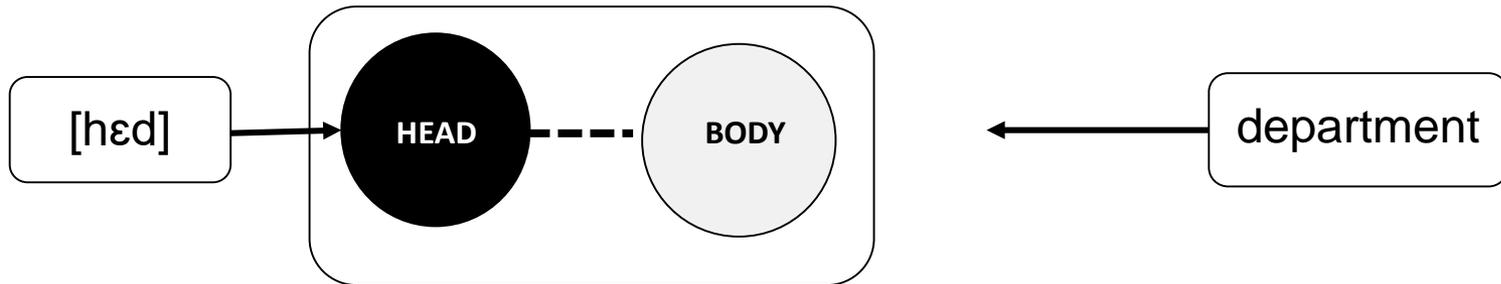
Conceptual integration

(1)   head of a person

(2)   head of a snake

(3)   head of department
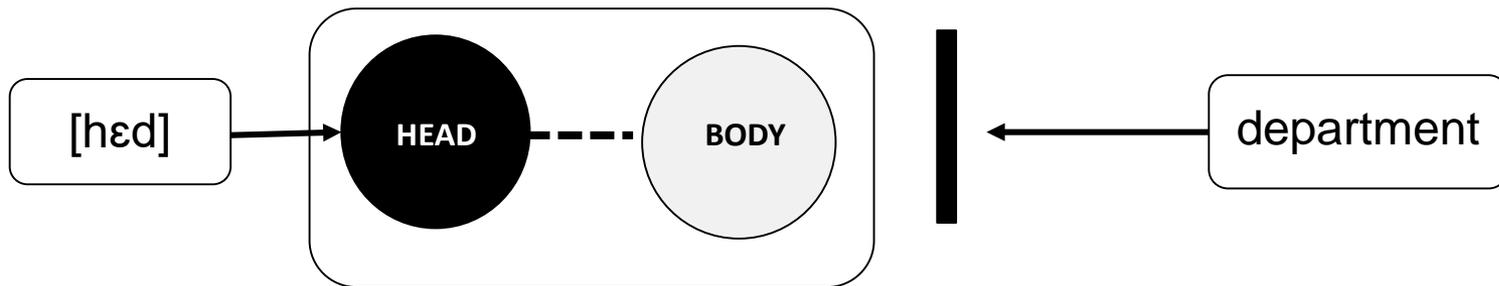
Conceptual integration

(1)   head of a person

(2)   head of a snake

(3)   head of department
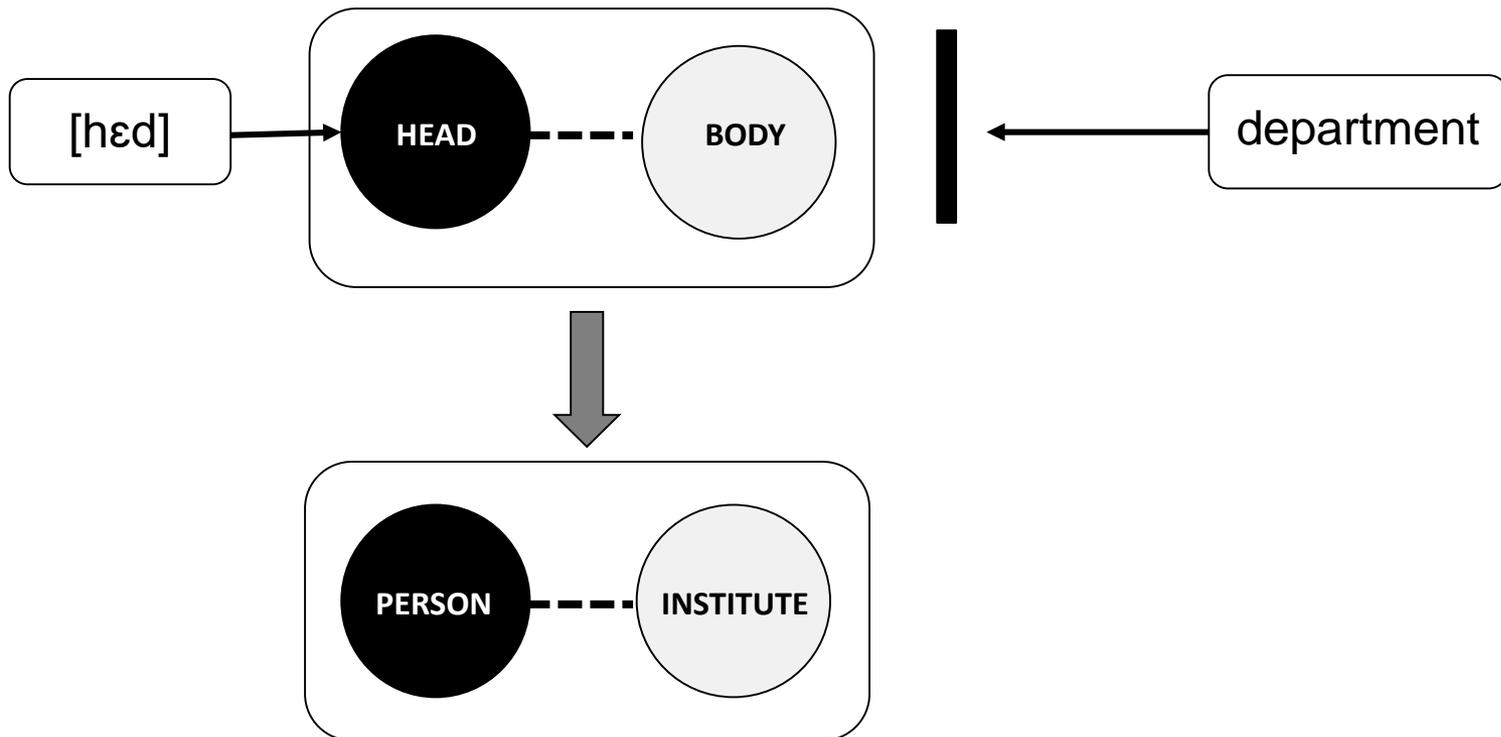
Conceptual integration

(1)   long hair

Conceptual integration

(1)　　　long hair

Conceptual integration

(1)　　long hair

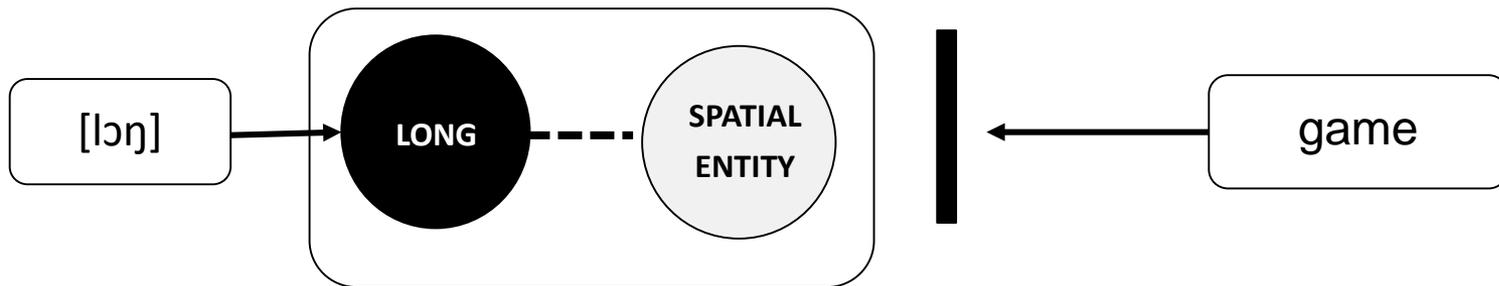# Conceptual integration
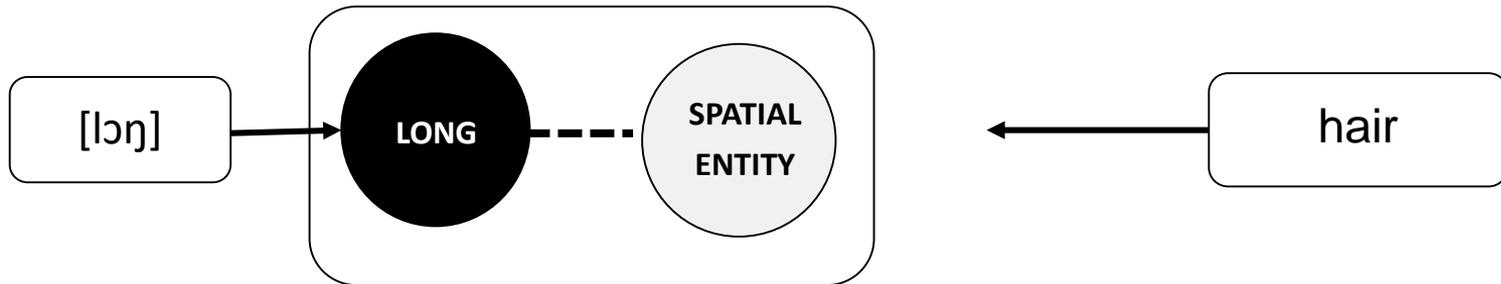
(1)　　　long hair

Conceptual integration

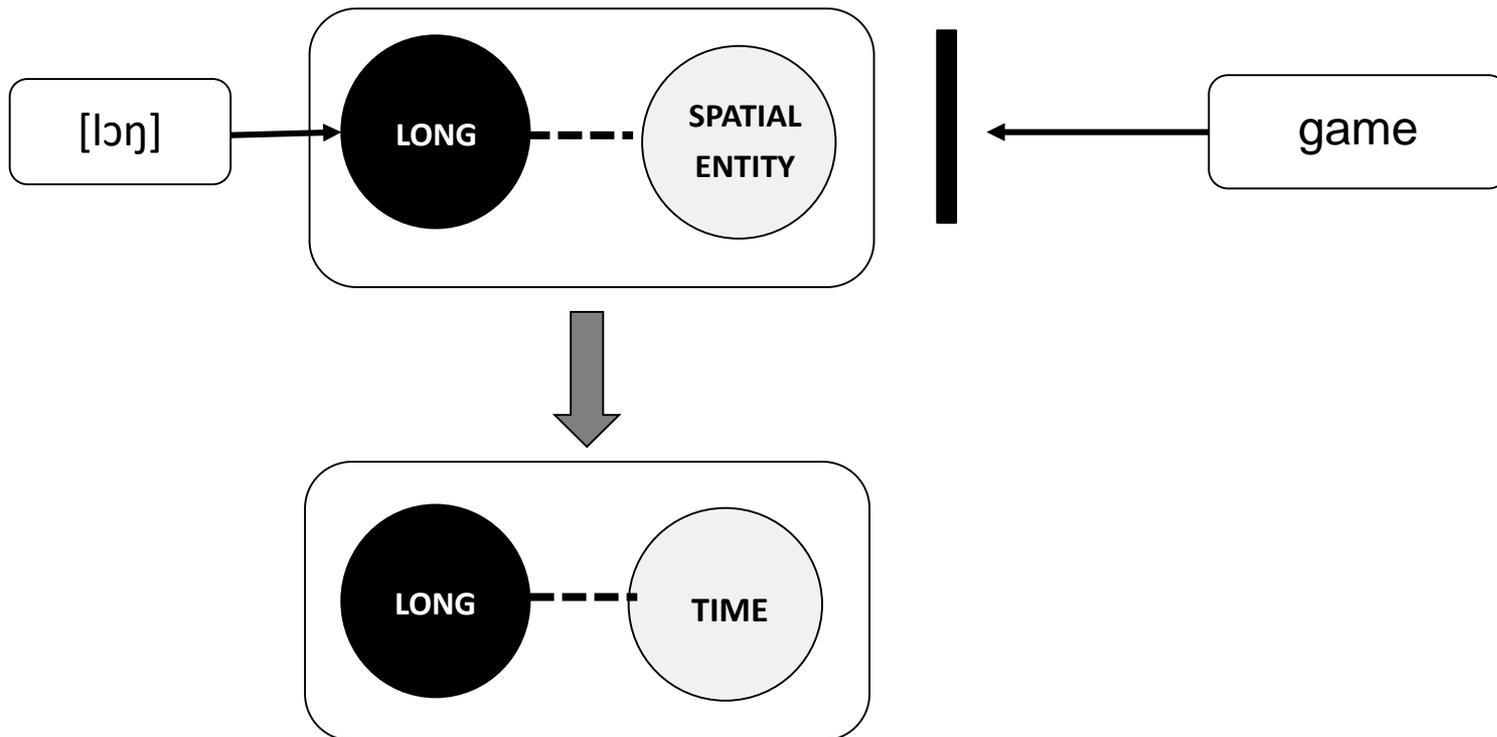(1)   long hair
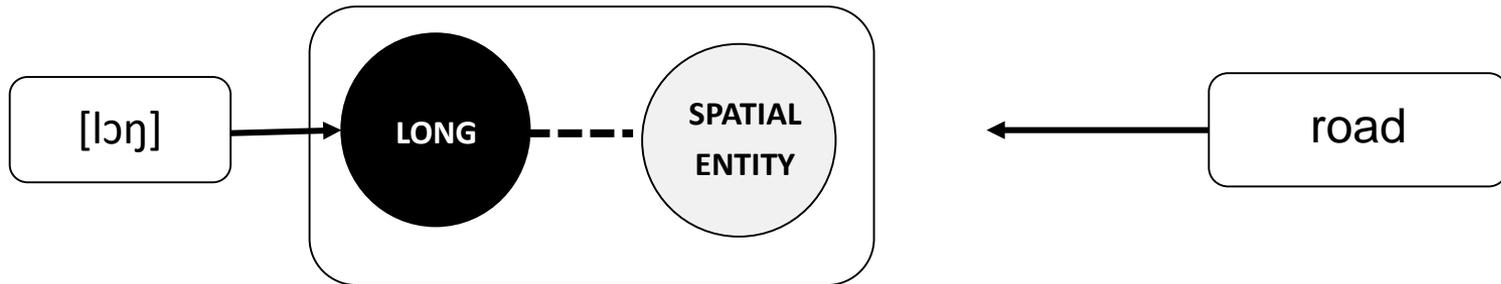
(2)   long road

Conceptual integration
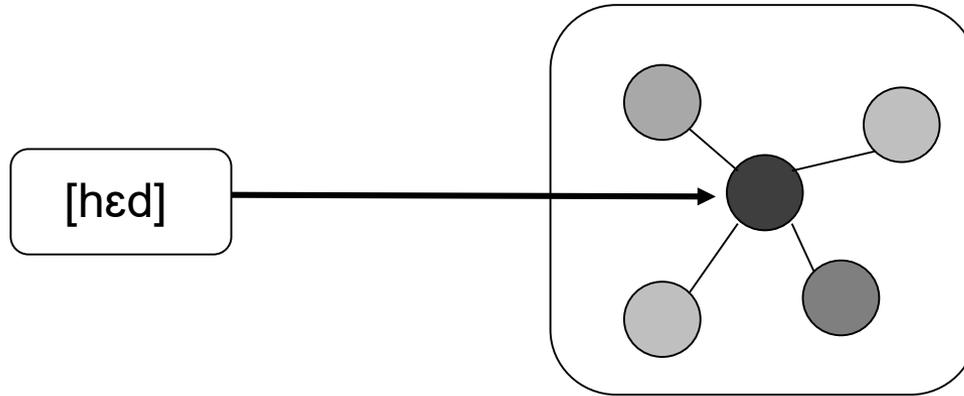
(1)   long hair

(2)   long road

(3)   long game

Conceptual integration
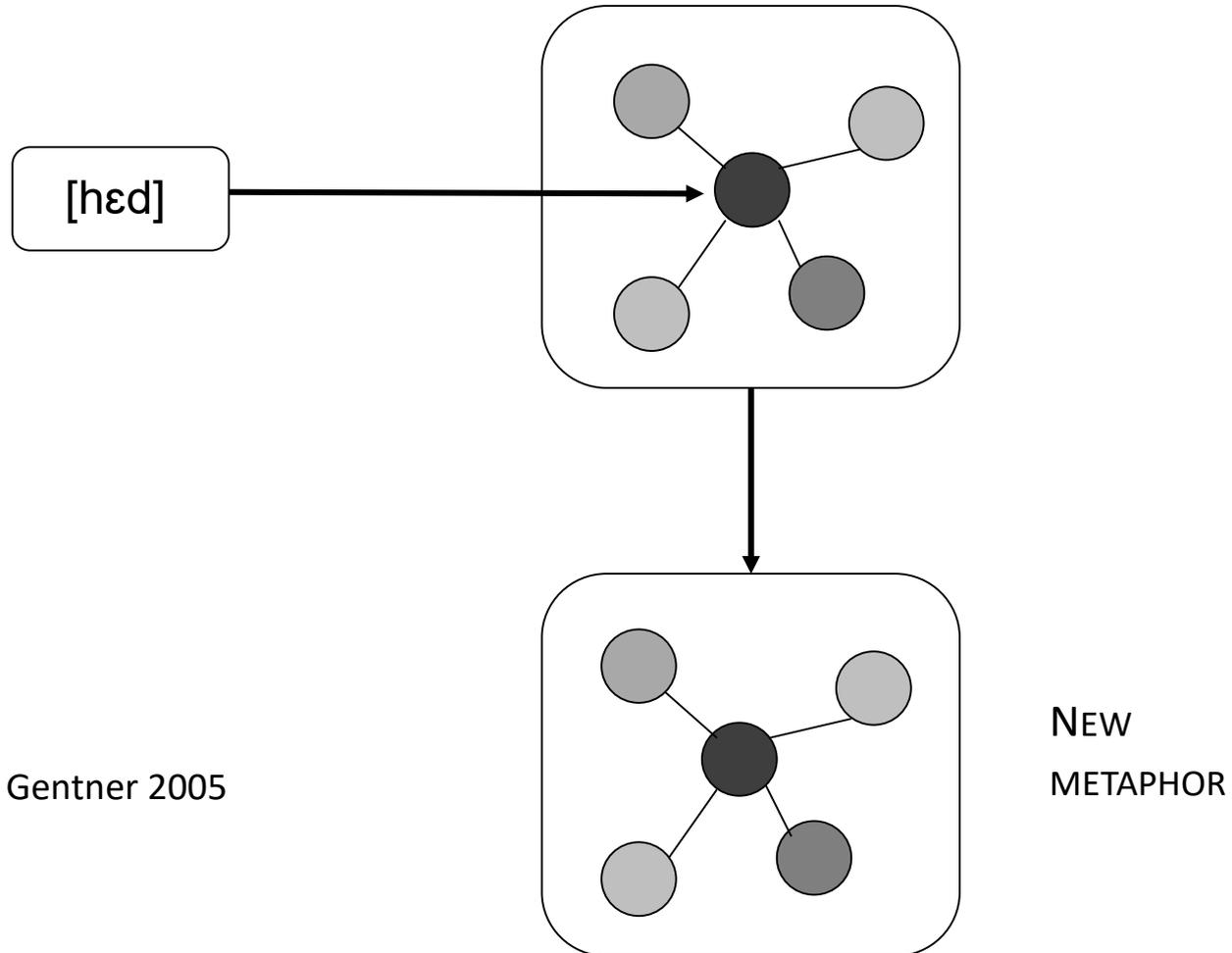
(1)   long hair

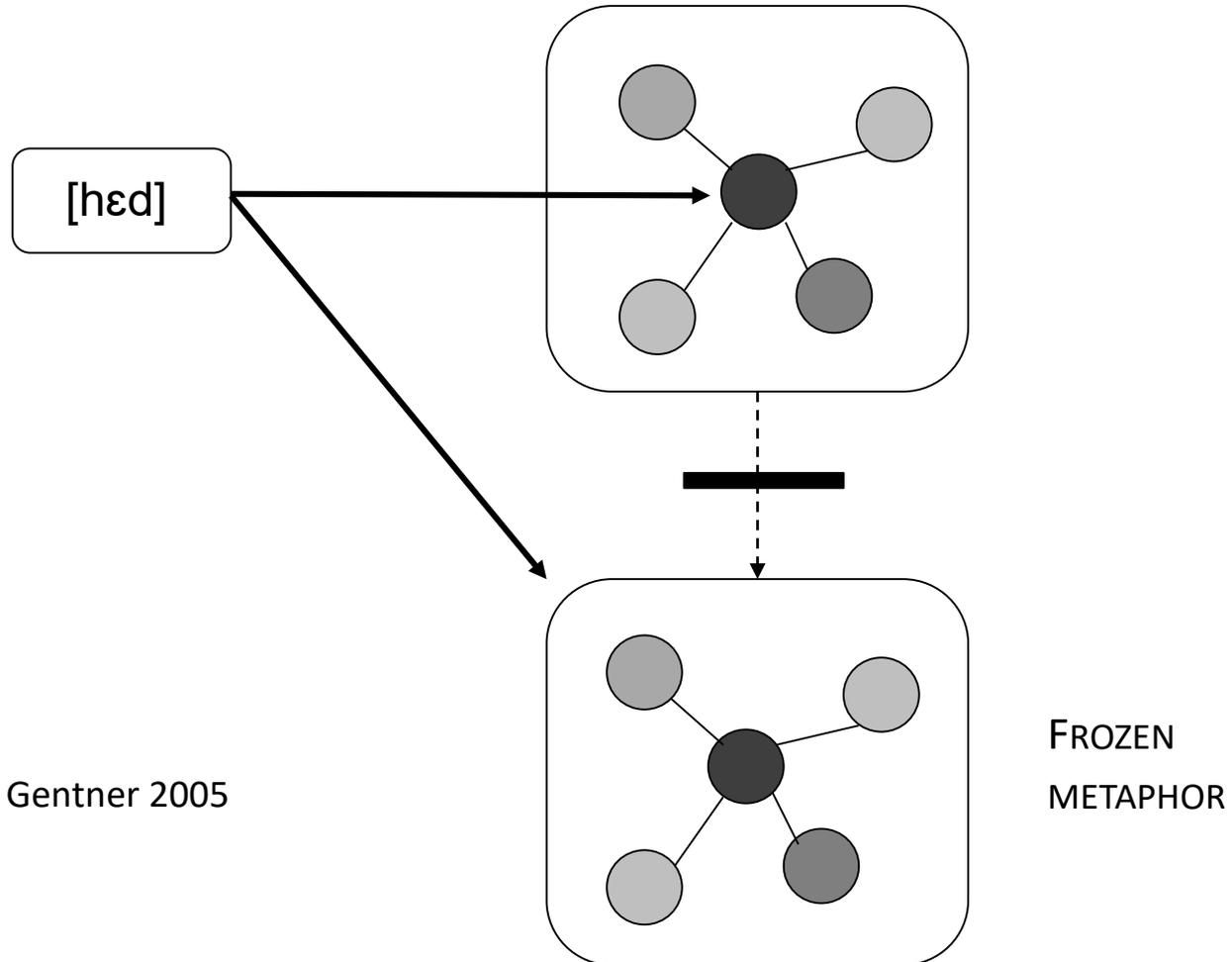(2)   long road

(3)   long game

Development of metaphor

Bowdle and Gentner 2005

Development of metaphor

[hɛd]

Bowdle and Gentner 2005

NEW
METAPHOR

Development of metaphor


[hɛd]

Bowdle and Gentner 2005

FROZEN

METAPHOR

Conceptual integration

➢ Polysemy is based on metaphorical shifts that are **triggered by the incompatibility** of a lexeme and its context.

(1)   head of body
(2)   head of department
(3)   head of hammer
(4)   head of flower
(5)   head of parade
(6)   head of phrase
(7)   to head a committee
(8)   to head a list

Conceptual integration

"polysemy network" (= "semantic map")

Head
[parade]

Head
[body]

Head
[phrase]
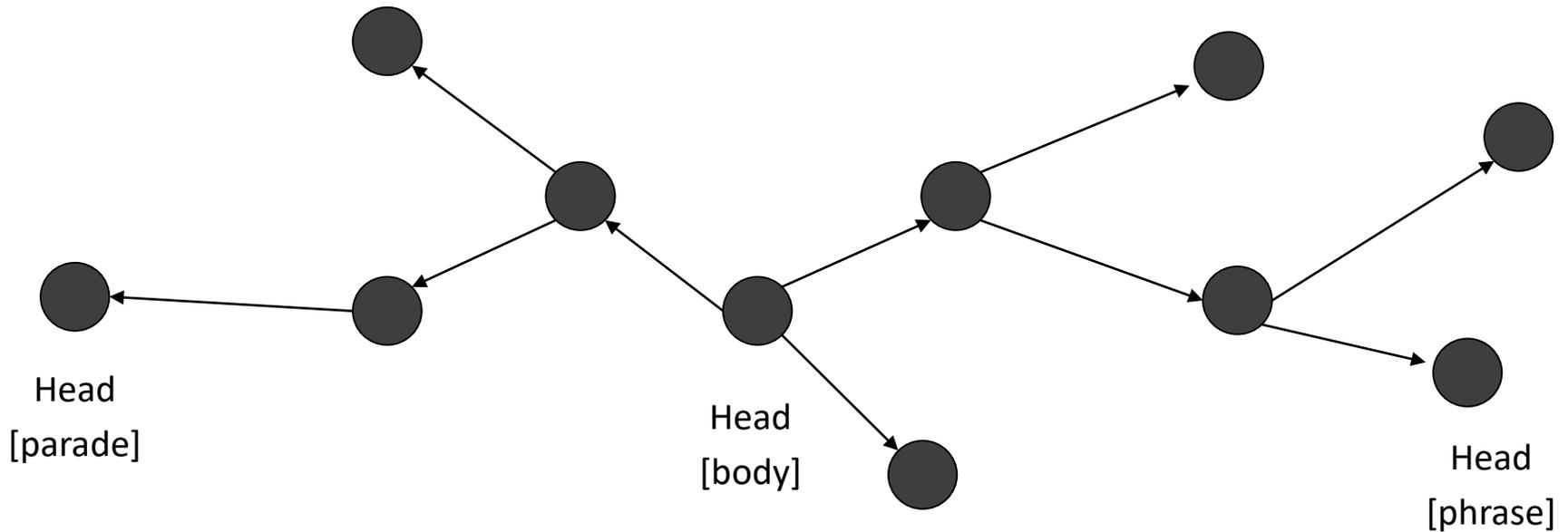
Summary

- Symbolic associations are derived from the use of phonetic cues in meaningful contexts.

- They are the joint product of several cognitive processes including metaphor, conceptual integration and automatization.

- Since many lexemes are used across different contexts, they are usually associated with **multiple paths of semantic interpretation** that are strengthened by frequency of occurrence.

- The result of this is a **symbol that can guide a language user along various paths of semantic interpretation** that are contingent on the context.
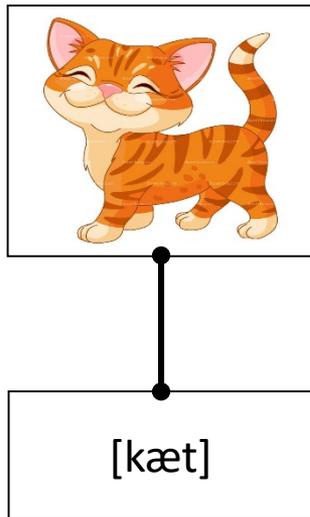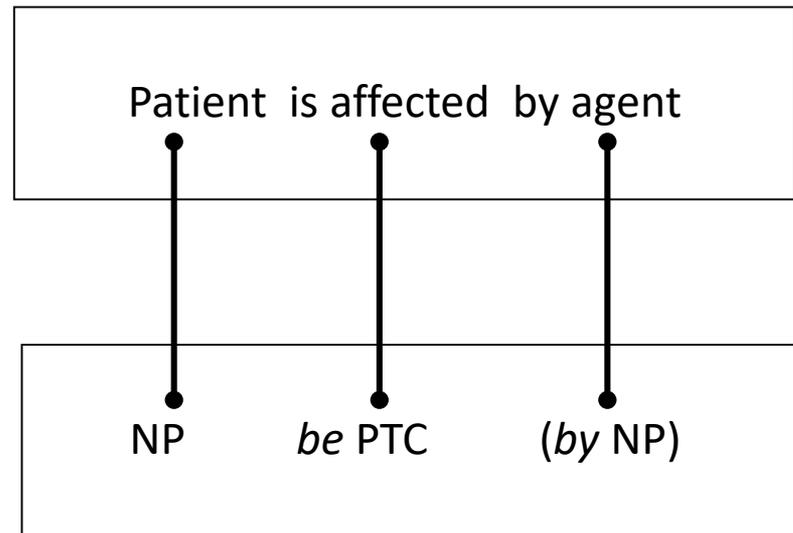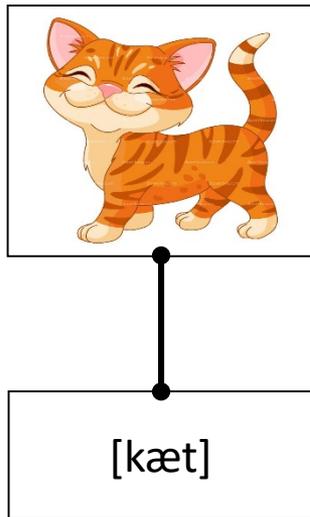
Constructions

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In the construction-based literature, it is commonly assumed that constructions have meaning (like lexemes).

Constructions

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[kæt]

Constructions

In the construction-based literature, it is commonly assumed that constructions have meaning (like lexemes).

[kæt]

Patient is affected by agent

NP   *be* PTC   (*by* NP)

Constructions

This view is inadequate for two reasons:

- First, neither lexemes nor constructions "have" meaning but serve to "create" meaning.
- Second, the psychological processes that are involved in the creation of meaning are different for lexemes and constructions.

Lexemes provide access to an open-ended network of concepts.

Constructions guide the language users' interpretation of lexemes.

Construction

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Lexemes provide access to an open-ended network of concepts.

Constructions guide the language users' interpretation of lexemes.

CONCEPTUAL INTEGRATION

| PERSON | → | ACTION | → | OBJECT | → | LOCATION |
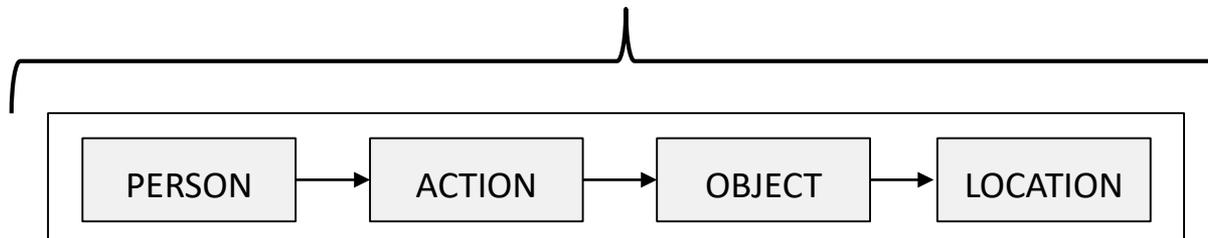
Conclusion

Conclusion

Constructions are dynamic networks that involves three different types of associations:

- Symbolic relations
- Sequential relations
- Taxonomic relations

The constructions-based literature has emphasized the parallels between lexemes and constructions: Both can be seen as "signs".

➤ But they are very different types of signs.

Thank you