Memory Processing and the Visual Impedance Effect

Rebecca Albrecht Holger Schultheis Wai-Tat Fu

Universities of Freiburg, Bremen and Illinois

17. Juli 2015

Imaginary Scenario (1)

Imagine you want to find *Resnik House* at CMU campus!
You forget your map at home but you already know where the *University Center* is.

Person 1: I know that *West Wing* is to the right of the *University Center*.

Person 2: I know that *West Wing* is to the left of *Resnik*

Imaginary Scenario (1)

Imagine you want to find *Resnik House* at CMU campus!
You forget your map at home but you already know where the *University Center* is.

Person 1: I know that *West Wing* is to the right of the *University Center*.

Person 2: I know that *West Wing* is to the left of *Resnik*

Are you now able to find Resnik?

Imaginary Scenario (1)

Imagine you want to find *Resnik House* at CMU campus!
You forget your map at home but you already know where the *University Center* is.

Person 1: I know that *West Wing* is to the right of the *University Center*.

Person 2: I know that *West Wing* is to the left of *Resnik*

Are you now able to find Resnik?

University Center	West Wing	Resnik

Imaginary Scenario (2)

Now you want to make sure that you will live in a dorm where the rooms are darker than the rooms in the *University Center*.

Person 1: I know that *West Wing* is darker than the *University Center*.

Person 2: I know that *West Wing* is brighter than *Resnik*.

Imaginary Scenario (2)

Now you want to make sure that you will live in a dorm where the rooms are darker than the rooms in the *University Center*.

Person 1: I know that *West Wing* is darker than the *University Center*.

Person 2: I know that *West Wing* is brighter than *Resnik*.

Do you know whether Resnik is darker than the University Center?

Imaginary Scenario (2)

Now you want to make sure that you will live in a dorm where the rooms are darker than the rooms in the *University Center*.

Person 1: I know that *West Wing* is darker than the *University Center*.

Person 2: I know that *West Wing* is brighter than *Resnik*.

Do you know whether Resnik is darker than the University Center?

Was this conclusion harder to draw?

Imaginary Scenario (2)

Now you want to make sure that you will live in a dorm where the rooms are darker than the rooms in the *University Center*.

Person 1: I know that *West Wing* is darker than the *University Center*.

Person 2: I know that *West Wing* is brighter than *Resnik*.

Do you know whether Resnik is darker than the University Center?

Was this conclusion harder to draw?

How did you represent this information?

Visual Impedance Hypothesis

Relations that elicit visual images without a component relevant to inference impede the process of reasoning.

(Knauff and Johnson Laird 2002)

Visual Impedance Hypothesis

Relations that elicit visual images without a component relevant to inference impede the process of reasoning.

(Knauff and Johnson Laird 2002)

But why?

Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.

Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.

Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

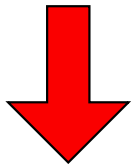
The hat is dirtier than the tie.
The tie is dirtier than the shoe.



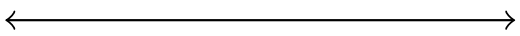
Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.



Hat	Tie	Shoe

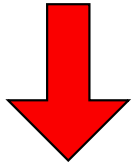


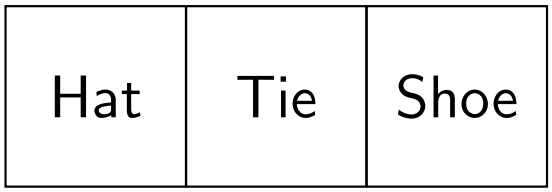
?

Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.





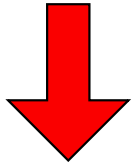
?

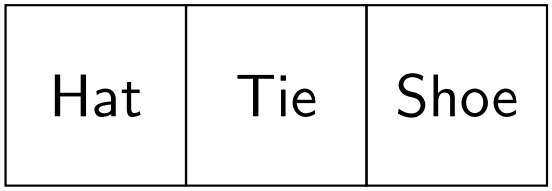
- Two different representations.

Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.





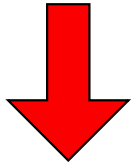
?

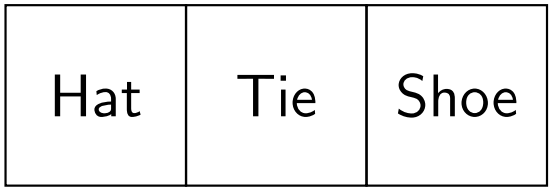
- Two different representations.
- Highly specific process.

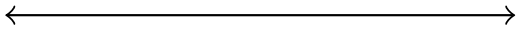
Mental Images and Mental Models

Johnson-Laird 1998, Kosslyn 2006, Knauff 2013

The hat is dirtier than the tie.
The tie is dirtier than the shoe.







?

- Two different representations.
- Highly specific process.

$\Rightarrow$ Visual Impedance is the result of the additional time necessary to construct a spatial mental model from a visual mental image! (Knauff 2013)

An alternative explanation

$\Rightarrow$ The visual impedance effect can be explained by one integrated representation and well-established memory mechanisms!

An alternative explanation

$\Rightarrow$ The visual impedance effect can be explained by one integrated representation and well-established memory mechanisms!

- Assume an **integrated, hierarchical memory structure** where
  - objects and relations are represented by *sets of features*,
  - features are necessary to represent the *content* of the premises.

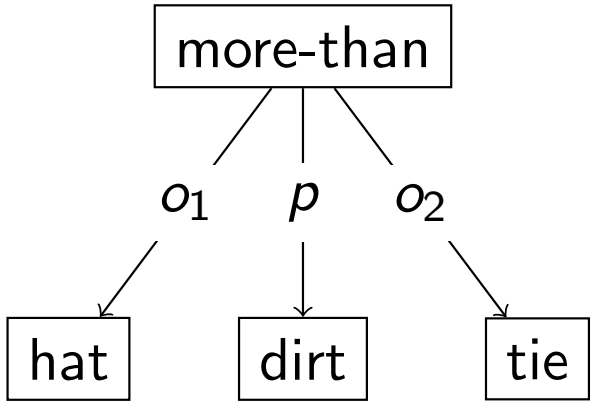
An alternative explanation

$\Rightarrow$ The visual impedance effect can be explained by one integrated representation and well-established memory mechanisms!

- Assume an **integrated, hierarchical memory structure** where
  - objects and relations are represented by *sets of features*,
  - features are necessary to represent the *content* of the premises.
- Assume **ACT-R spreading activation** where
  - *the more sources in working memory* spread activation into declarative memory *the more accessible the declarative memory items* are,
  - however *the more connections* exist between sources and memory items *the less accessible* declarative memory items are.

Representation of Relational Content

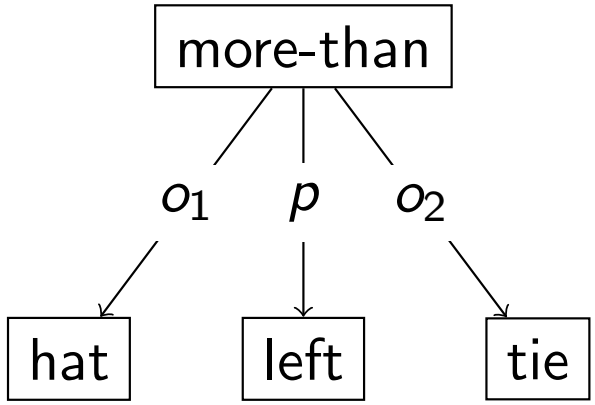
Visual Example:



The hat has *more dirt* than the tie

$content(dirt) = \{mud, brown, \ldots\}$

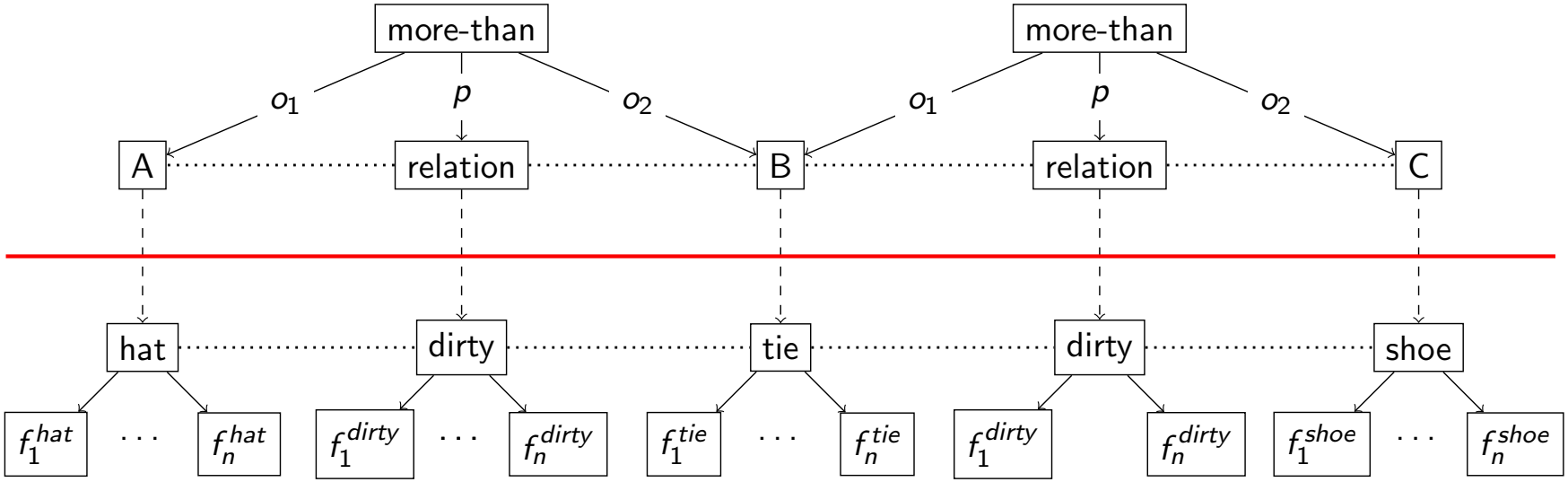
Spatial Example:



The hat is *more left* than the tie

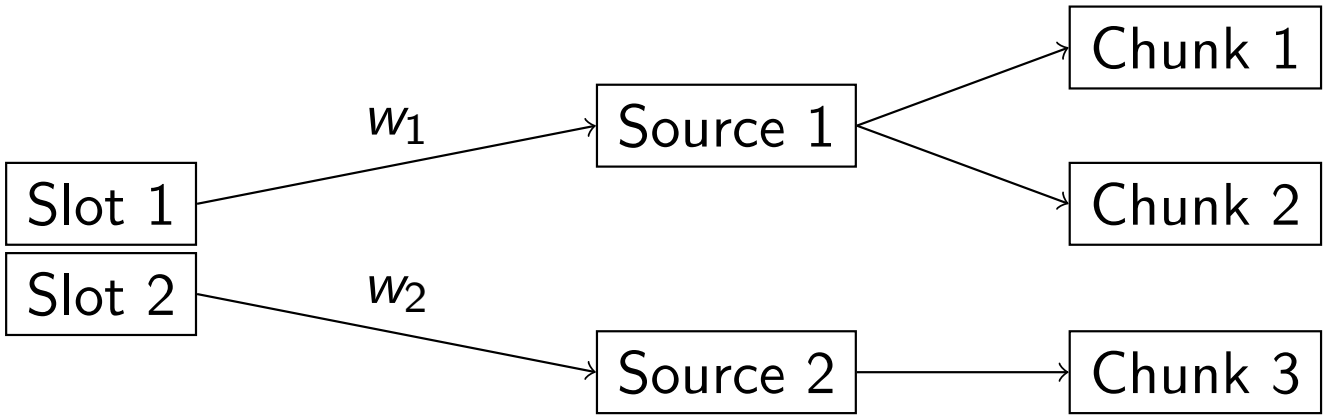
$content(left) = \{x\text{-}coordinate\}$

Hierarchical Memory Structure



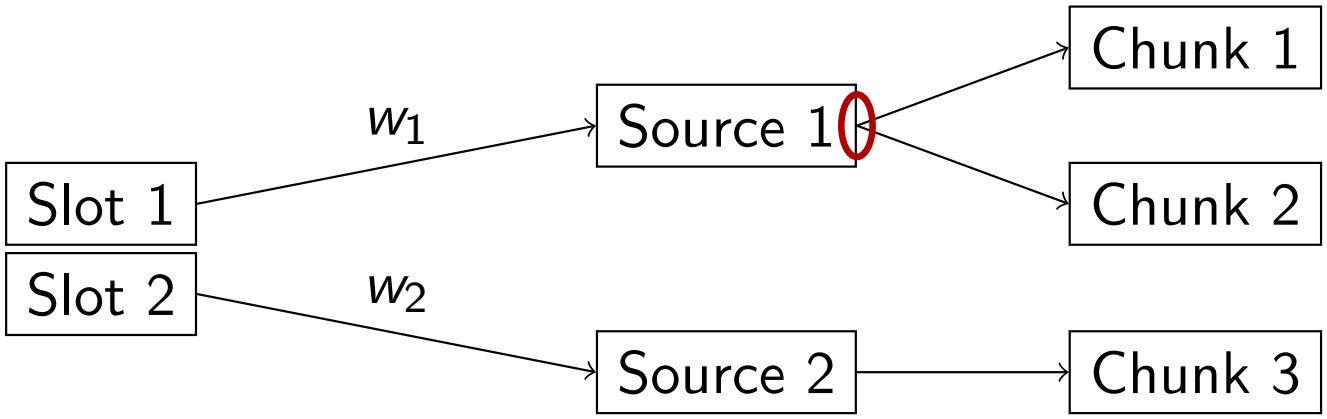
ACT-R Spreading Activation

Working Memory: Declarative Memory:



ACT-R Spreading Activation

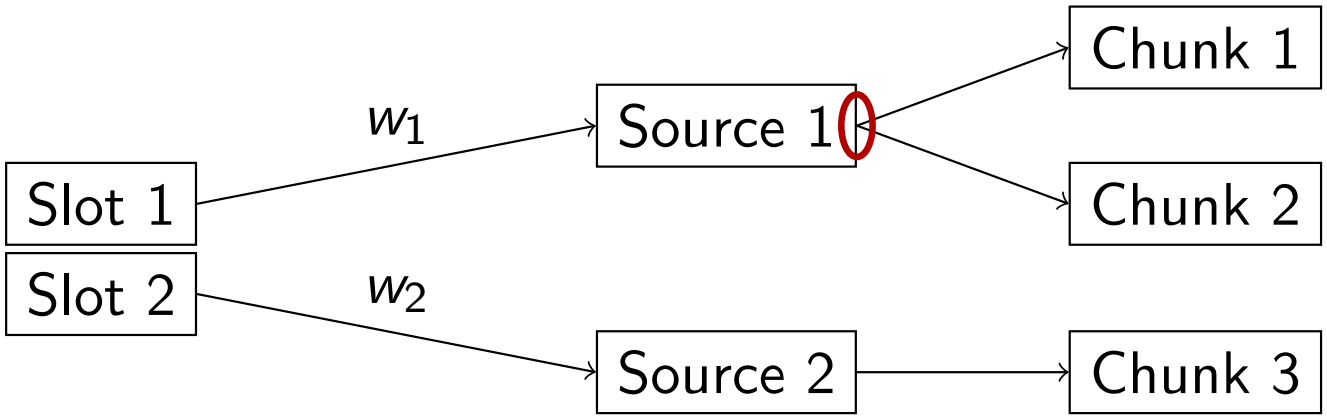
Working Memory: Declarative Memory:



- Number of outgoing connections determines the fan of a source.

ACT-R Spreading Activation

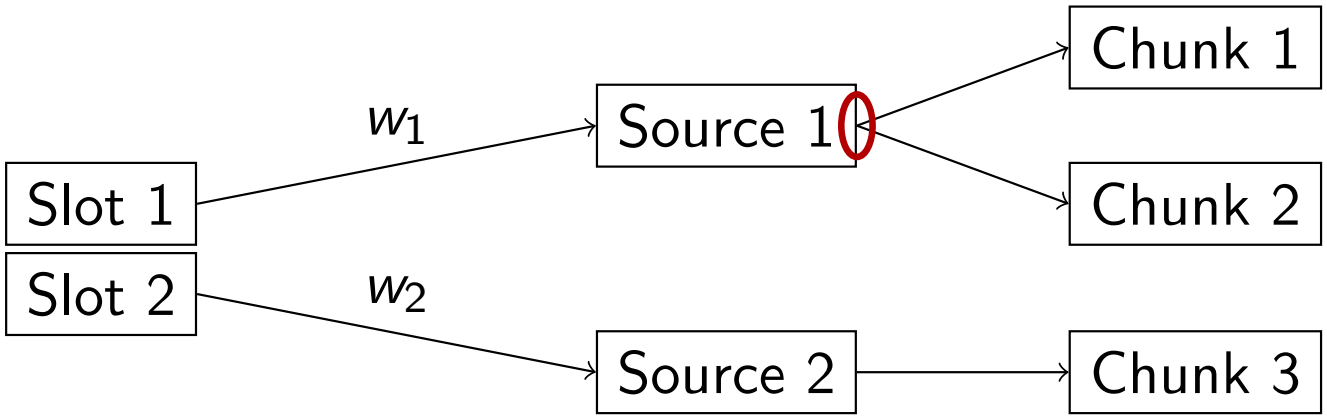
Working Memory: Declarative Memory:



- Number of outgoing connections determines the fan of a source.
- The higher the fan the less accessible are associated memory items.

ACT-R Spreading Activation

Working Memory: Declarative Memory:

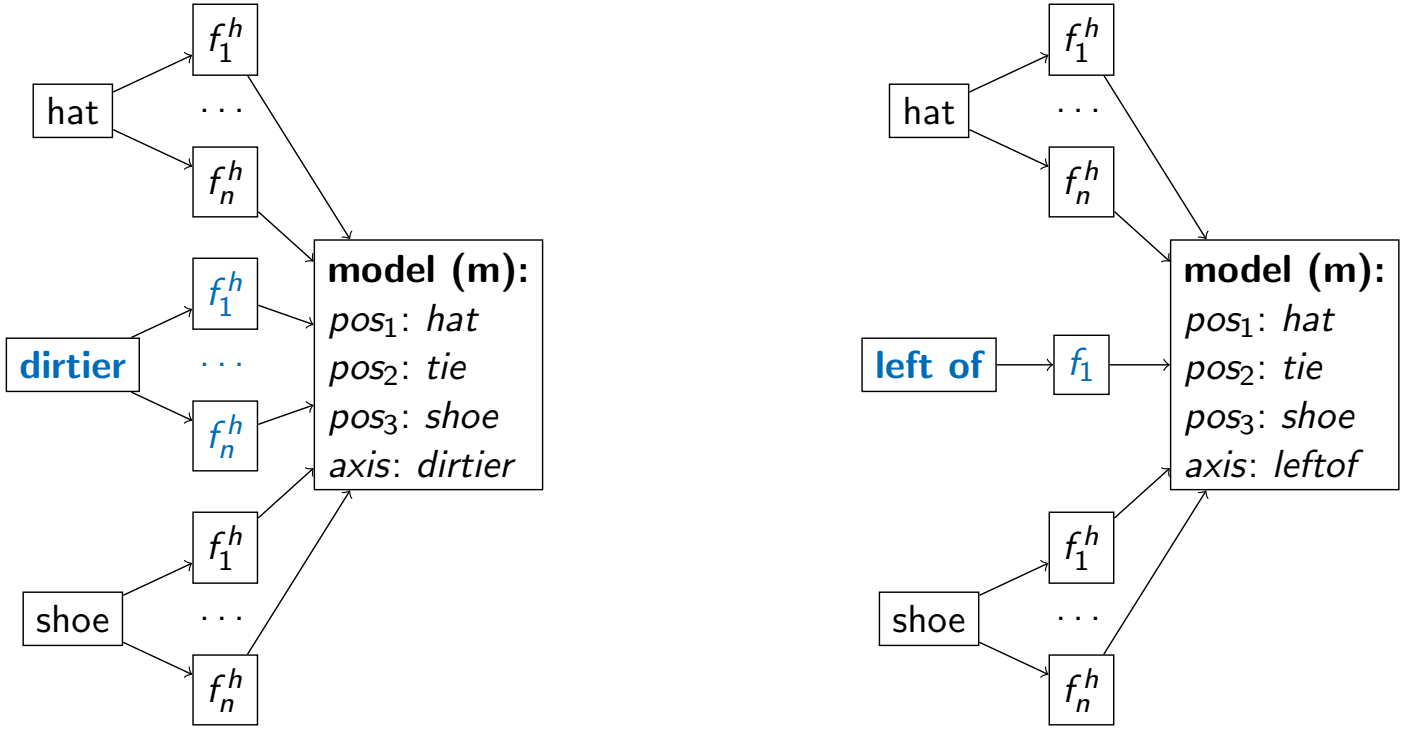


- Number of outgoing connections determines the fan of a source.
- The higher the fan the less accessible are associated memory items.

$\Rightarrow$ Chunks 1 and 2 are less accessible than chunk 3!

Knowledge Representation

Spreading activation



⇒ The less features are necessary to represent relational content the more accessible is a mental model chunk.

General Discussion

Is Visual Impedance really only a memory effect?

- One integrated, scalable representation for relational content.
- ACT-R spreading activation as a well-established memory mechanism.

$\Rightarrow$ **More parsimonious explanation.**

General Discussion

Is Visual Impedance really only a memory effect?

- One integrated, scalable representation for relational content.
- ACT-R spreading activation as a well-established memory mechanism.

$\Rightarrow$ **More parsimonious explanation.**

What about other reasoning effects?

Thank you for listening!