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!
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*Are you now able to find *Resnik*?*
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*Are you now able to find *Resnik*?*
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*. 
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?*
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.

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

Was this conclusion harder to draw?

How did you represent this information?
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

The hat is dirtier than the tie.
The tie is dirtier than the shoe.
The hat is dirtier than the tie.
The tie is dirtier than the shoe.
Mental Images and Mental Models

The hat is dirtier than the tie.
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Mental Images and Mental Models


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

Two different representations.
Highly specific process.

⇒ Visual Impedance is the result of the additional time necessary to construct a spatial mental model from a visual mental image!

(Knauff 2013)
Mental Images and Mental Models


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

- Two different representations.
The hat is dirtier than the tie. The tie is dirtier than the shoe.

- Two different representations.
- Highly specific process.

<table>
<thead>
<tr>
<th>Hat</th>
<th>Tie</th>
<th>Shoe</th>
</tr>
</thead>
</table>
Mental Images and Mental Models


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

- Two different representations.
- Highly specific process.

⇒ 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

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

⇒ 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:

```
more-than
 o₁  p  o₂
 hat  dirt  tie
```

The hat has *more dirt* than the tie

\[
\text{content}(dirt) = \{\text{mud, brown, \ldots}\}
\]

Spatial Example:

```
more-than
 o₁  p  o₂
 hat  left  tie
```

The hat is *more left* than the tie

\[
\text{content}(left) = \{x\text{-coordinate}\}
\]
Hierarchical Memory Structure

A more-than B

relation

o1 p o2

B more-than C

relation

o1 p o2

hat

dirty

tie

dirty

shoe

f_{hat}^{1} \ldots f_{hat}^{n} f_{dirty}^{1} \ldots f_{dirty}^{n} f_{tie}^{1} \ldots f_{tie}^{n} f_{dirty}^{1} \ldots f_{dirty}^{n} f_{shoe}^{1} \ldots f_{shoe}^{n}
ACT-R Spreading Activation

Working Memory:

- Slot 1
- Slot 2

Source 1

Declarative Memory:

- Chunk 1
- Chunk 2
- Chunk 3

Number of outgoing connections determines the fan of a source. The higher the fan the less accessible are associated memory items. ⇒ Chunks 1 and 2 are less accessible than chunk 3!
Number of **outgoing connections** determines the **fan** of a source.
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The higher the fan the less accessible are associated memory items.
Number of **outgoing connections** determines the **fan** of a source.

The **higher the fan** the **less accessible** are associated memory items.

⇒ Chunks 1 and 2 are less accessible than chunk 3!
The less features are necessary to represent relational content the more accessible is a mental model chunk.

⇒ Knowledge Representation

Spreading activation
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.

⇒ **More parsimonious explanation.**
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.

⇒ More parsimonious explanation.

What about other reasoning effects?
Thank you for listening!