

Investigations and assumptions
on
hearing effort

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Motivation

- Hearing impaired subjects complain about high listening effort in noisy conditions
- Hearing effort is independent from speech intelligibility
- Is difficult to measure!!



Definition

- Hearing effort is
 - the effort that is needed to extract a certain amount of information carried in a noisy auditory stream of information
 - correlated to the cognitive load to perform the task



Investigation methods

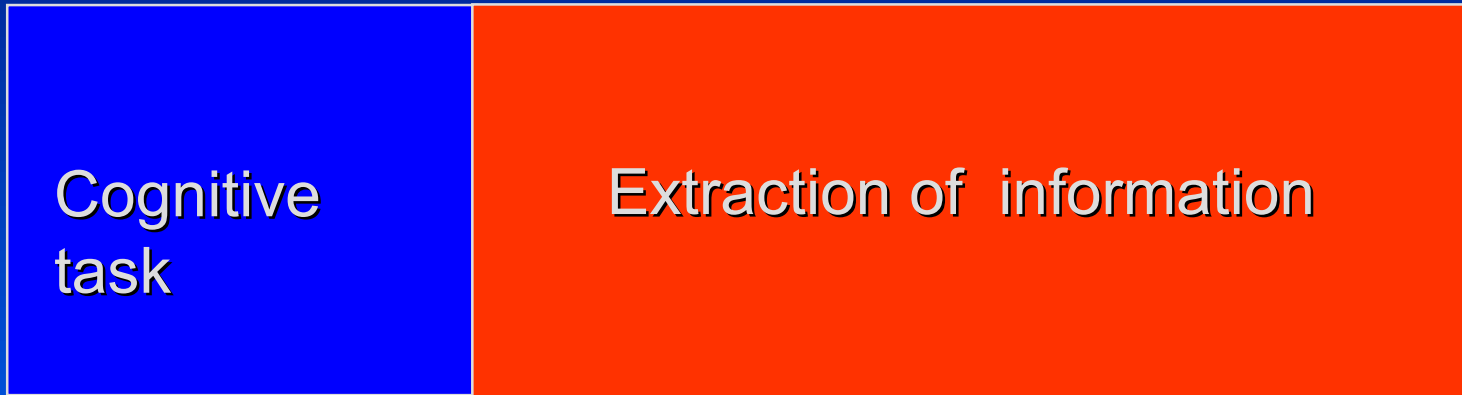
- Subjective scaling
- Physiological measures
 - Pulse frequency
 - Skin resistance
 - Pupillometrie
- Capacity model measures
 - Indirect measure



Capacity model (e.g. Kahnemann, 1973)

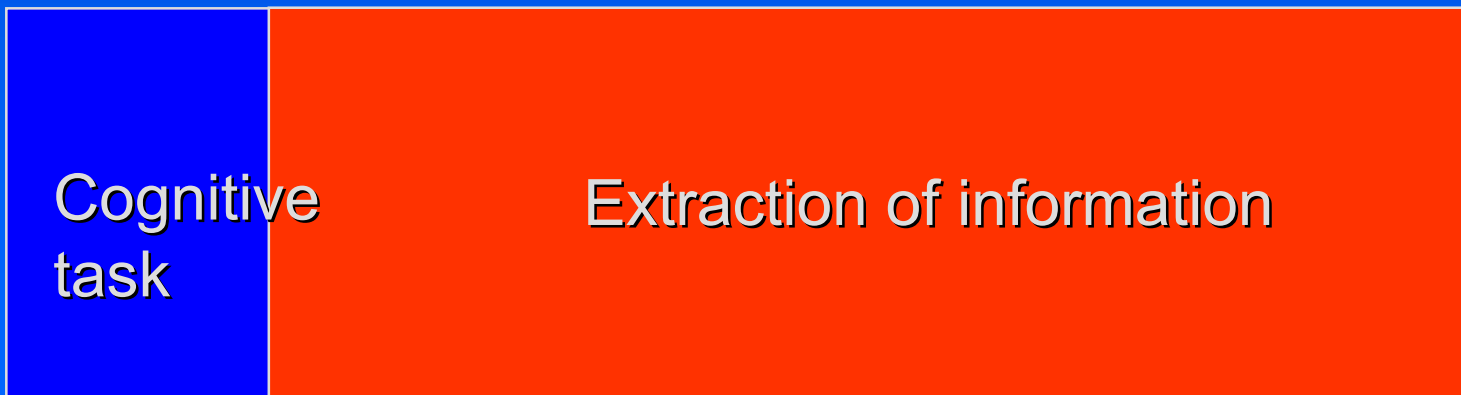
Condition I:

Little distortion



Condition II:

More distortion





Method I: Memorization of sequences

- Presentation of sequences of digits in free-field
- Digits from 1 to 9 (*/7*)

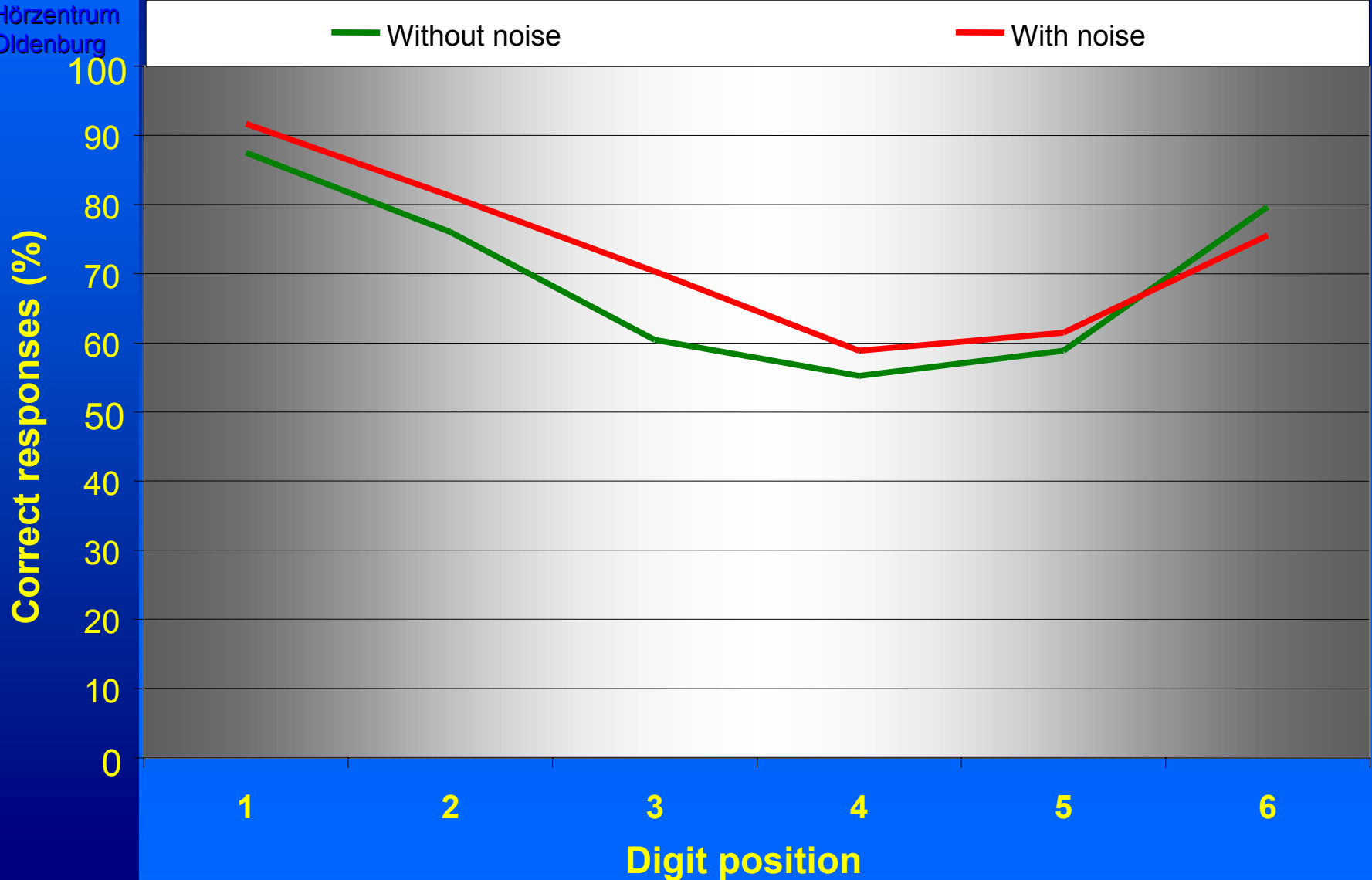
1 4 6 9 3 5

- Task: Repeat digits in correct order
- 100% recognition rate



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A typical result:





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Interpretation

- Subjects are very motivated
 - Task is a challenge
 - the worse the condition the higher the effort
- ➡ subject perform better in the worse condition
- ➡ go to the limit!



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Method II: Dual Task II

Visual task (reaction time):

aB RD ee TS fG ss Qz FG hg ZZ gd QS DG dD dg DG as aq

Auditory task (repetition rate):

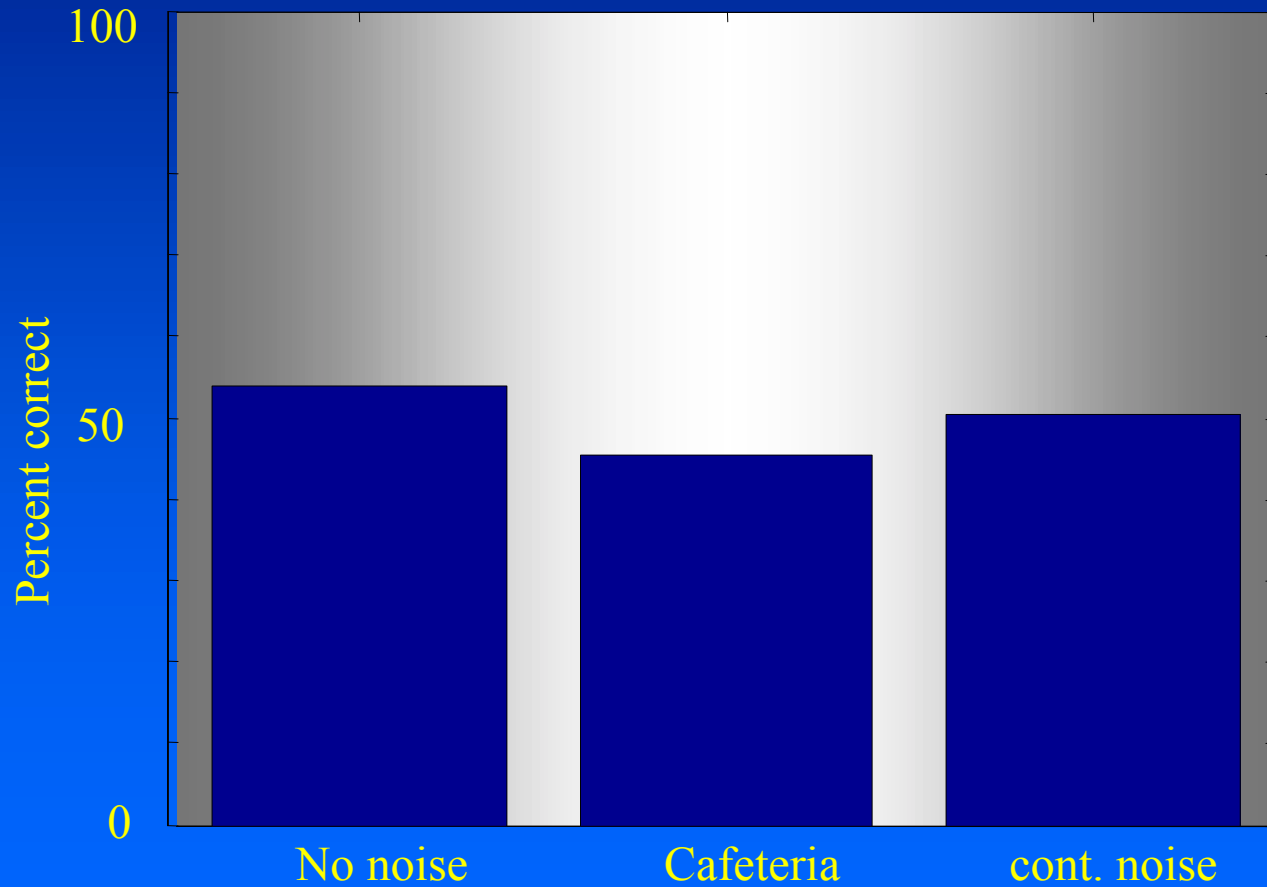
Zutt Beck Diff Gamm Nitt Fess Supp Rack Femm Lutt Witt Rupp

Compare results of the tasks for
different acoustical conditions



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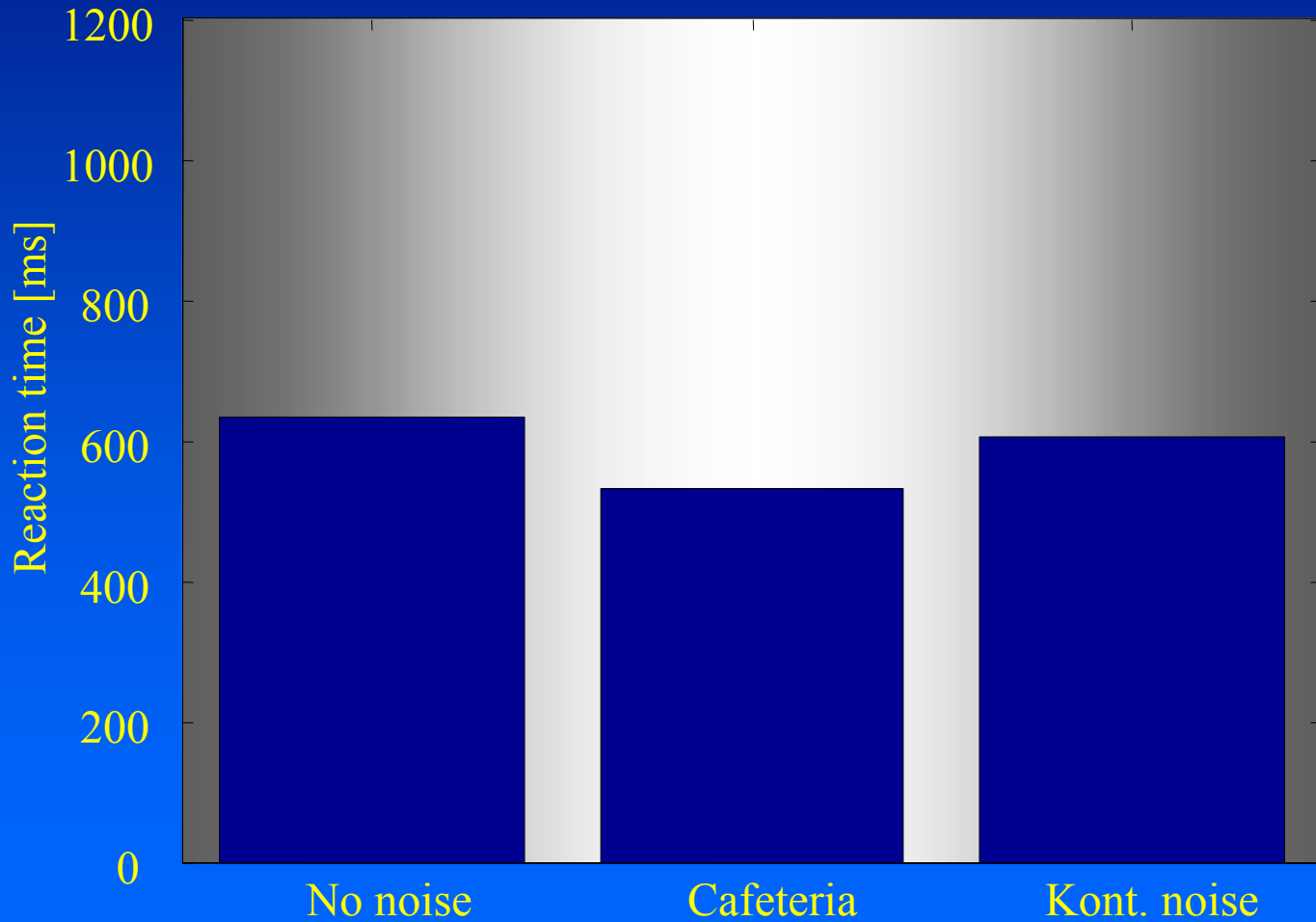
Auditory modality: Correct repetition





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Visual modality: Reaction time





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Method II: Dual Task II

Visual domain (reaction time):

aB RD ee TS fG ss Qz FG hg ZZ gd QS DG dD dg DG as aq

Auditory task (reaction time):

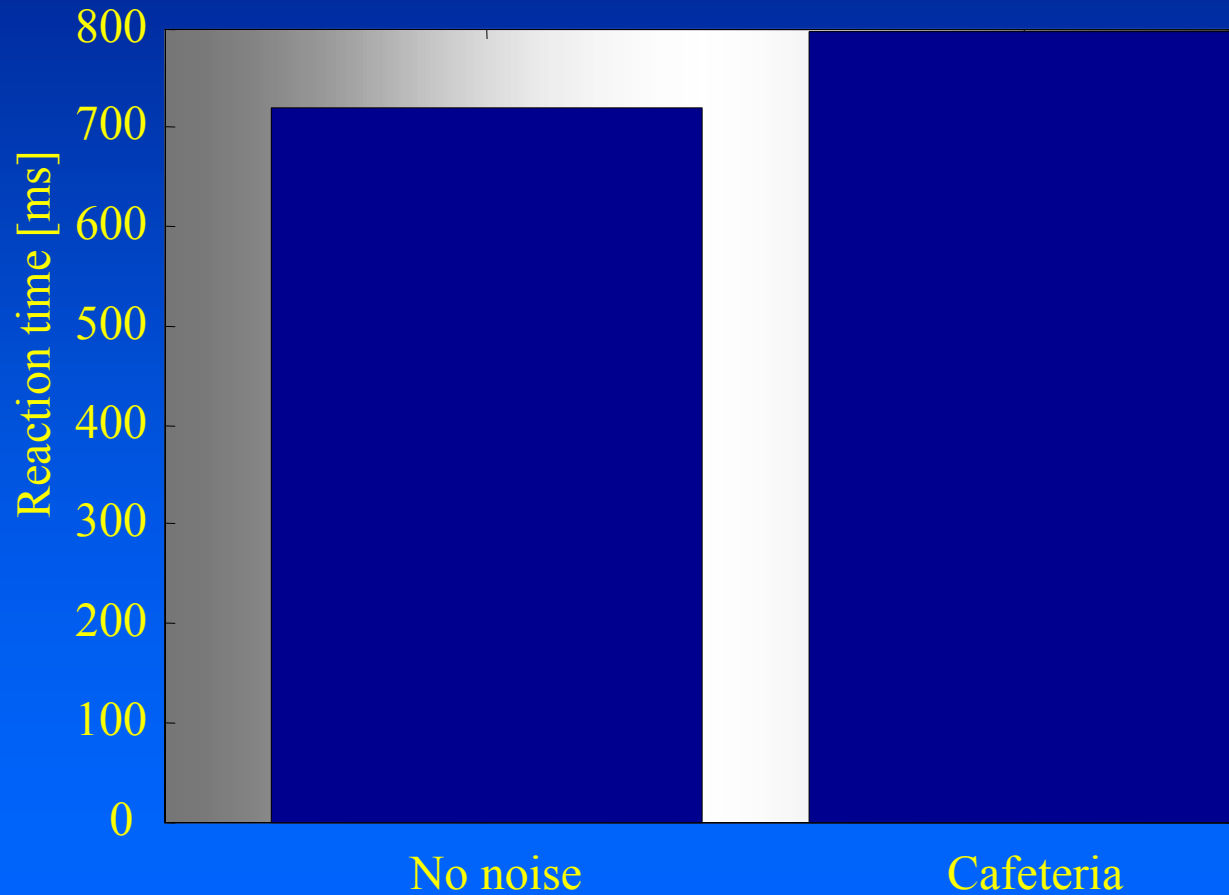
Zutt Beck Diff Gamm Nitt Fess Supp Rack Femm Lutt Witt Rupp

Compare results of the tasks for
two different acoustical conditions



Auditory modality: Reaction time

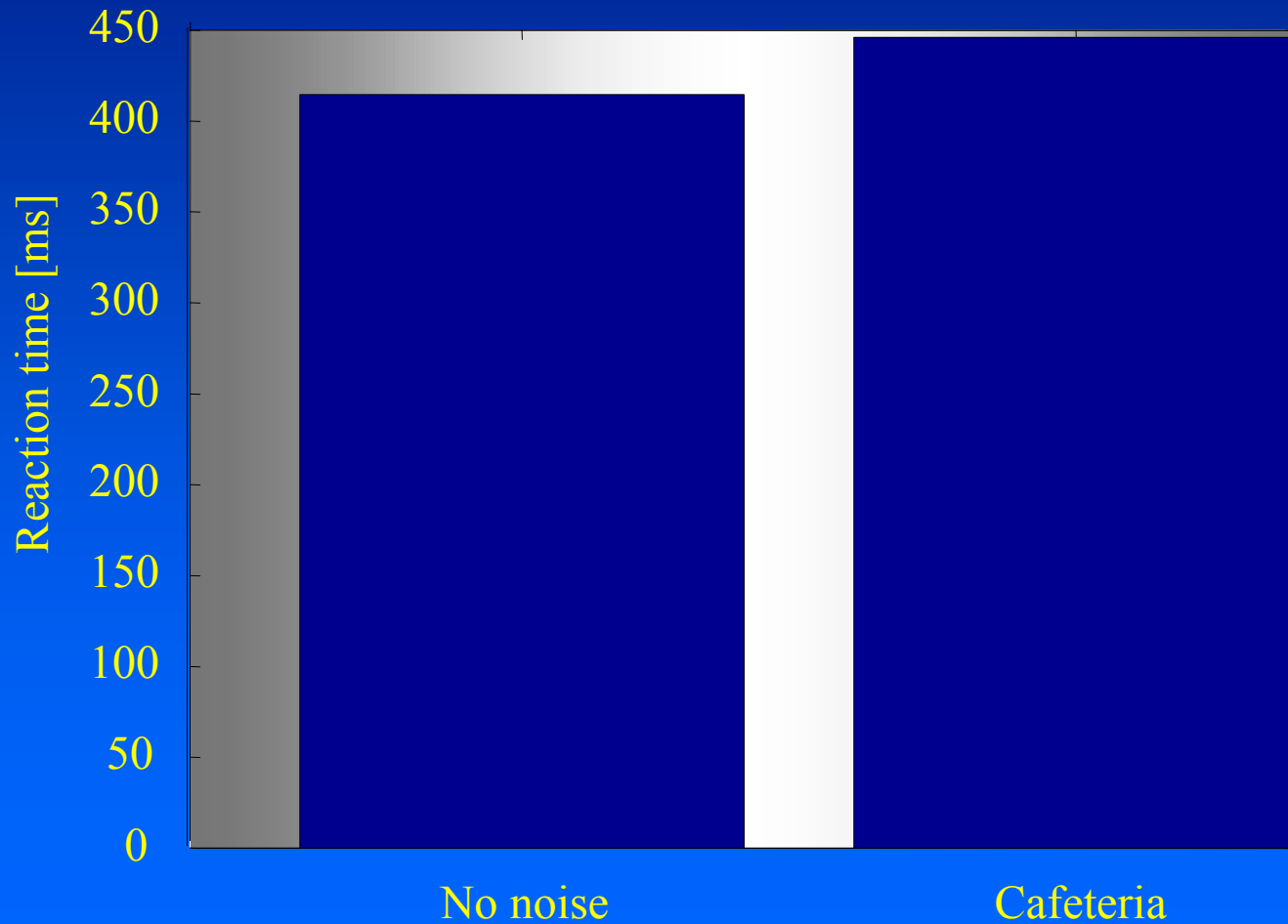
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Visual modality: Reaction time





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A general problem

Speech
intelligibility

100%

50%

0%

SNR

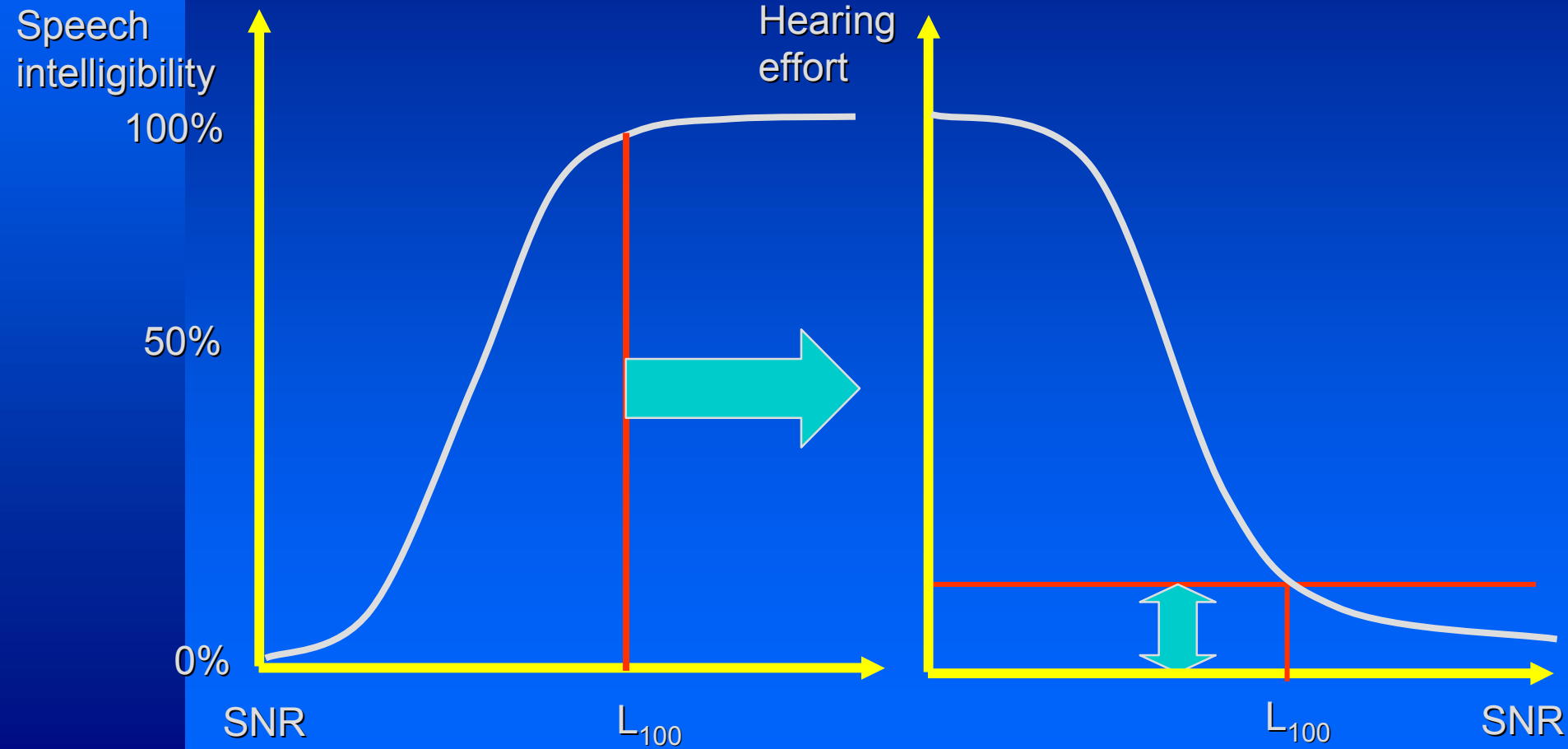
L_{100}

Hearing
effort



L_{100}

SNR





Components of Hearing Effort

- **> 100 % speech intelligibility**
 - Effort of eliminating noise from the auditory channel

- **< 100 % speech intelligibility**
 - Effort of adding missing information by context knowledge (high cognitive load)



Method III: Subjective Scaling

- Hearing effort must be measured for $< 100\%$ SI
- Subjective scaling measures hearing effort accurately
- Measure the subjectively perceived effort at SNRs from 0% to 100% SI



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To be continued...

**Thank you for your
attention!**