The University of Nottingham

Modelling and predicting the visual demand of in-vehicle information systems

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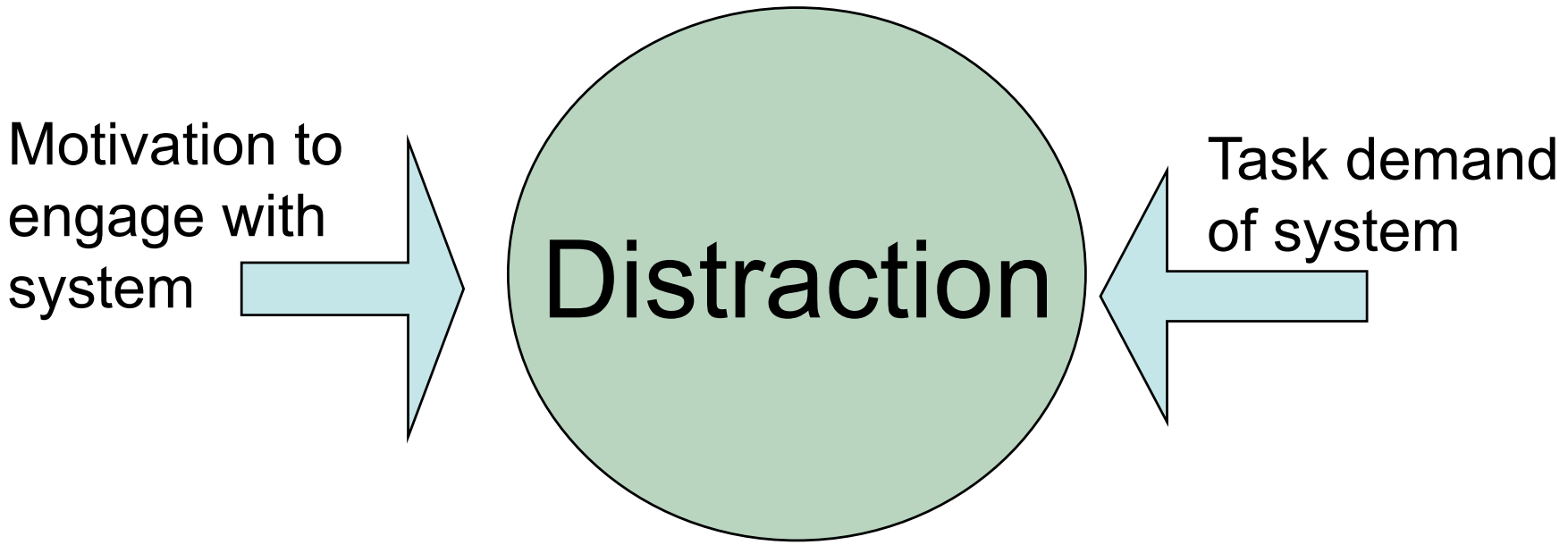
Measuring distraction
(Pettitt, Burnett and Stevens, 2006)



What methods are available for use in the design & evaluation of in-car user-interfaces?

Non-user methods, e.g.

- Guidelines/checklists
- Expert assessment
- Modelling

User-based methods, e.g.

- Focus groups
- Road/simulator trials
- Occlusion

The GOMS Keystroke level model
Card, Moran and Newell (1983)

- The Keystroke level model (KLM) is one of the family of GOMS models
- KLM predicts *task times* for a given user interface
  - Tasks are broken down into fundamental operators (e.g. keying, pointing, mentally preparing)
  - Mean time values available for different operators
  - Predicted task time is calculated by describing operators and summing together average times
  - Assumes error-free performance

KLM and in-car interfaces

- KLM can predict the time taken to achieve tasks with in-car user-interfaces when stationary (*static task time*)
- Static task times correlates with the following safety-related measures:
  - Glance frequency
  - Total Glance time
  - Dynamic task time
- Static task time does *not* relate well to other safety-related measures:
  - Glance duration (mean, 85th percentile)
  - The % of task time spent with "eyes off road"
  - Glance rate (no./sec)

Occlusion technique

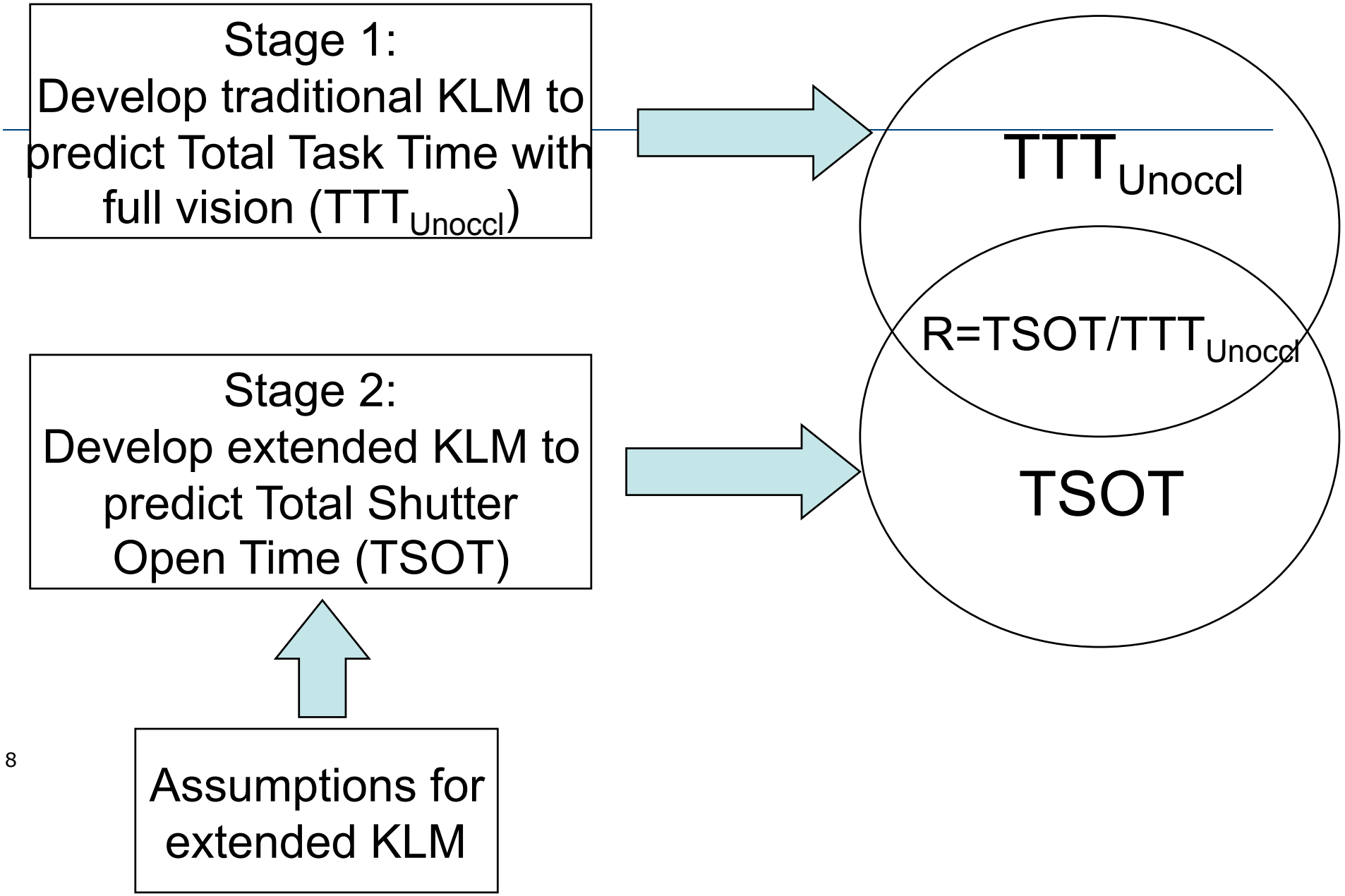
- Method aims to predict visual/manual demand of user-interfaces
- Participant completes task in a *stationary* vehicle whilst wearing LCD goggles
- ISO standard:
  - Cycle of 1.5 secs open/1.5 secs closed
- Metrics from method:
  - TSOT - Total Shutter Open Time
  - R - TSOT/Static Task Time (Resumability ratio)
- Concerns
  - Poor diagnostic ability of R
  - Requires a robust prototype

Using KLM with Occlusion

- Can we extend the KLM technique to model human performance under the interrupted vision conditions of occlusion trials?
- Aiming to realise benefits of:
  - KLM - Simple; Low cost; Can be used with basic prototypes early in design process

  and….
  - Occlusion - Standardised approach; Applicable to range of visual demand measures

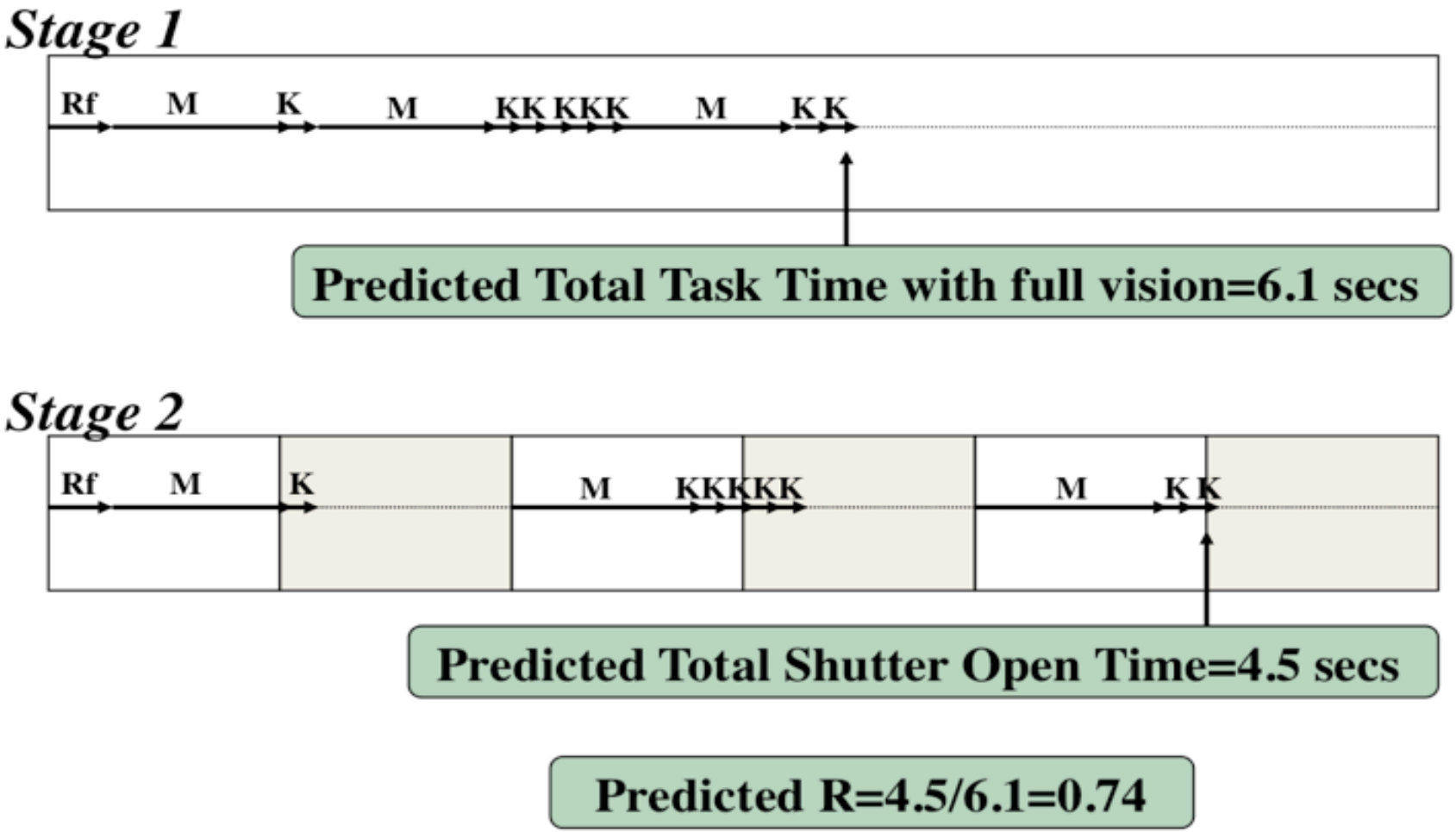
The extended KLM technique



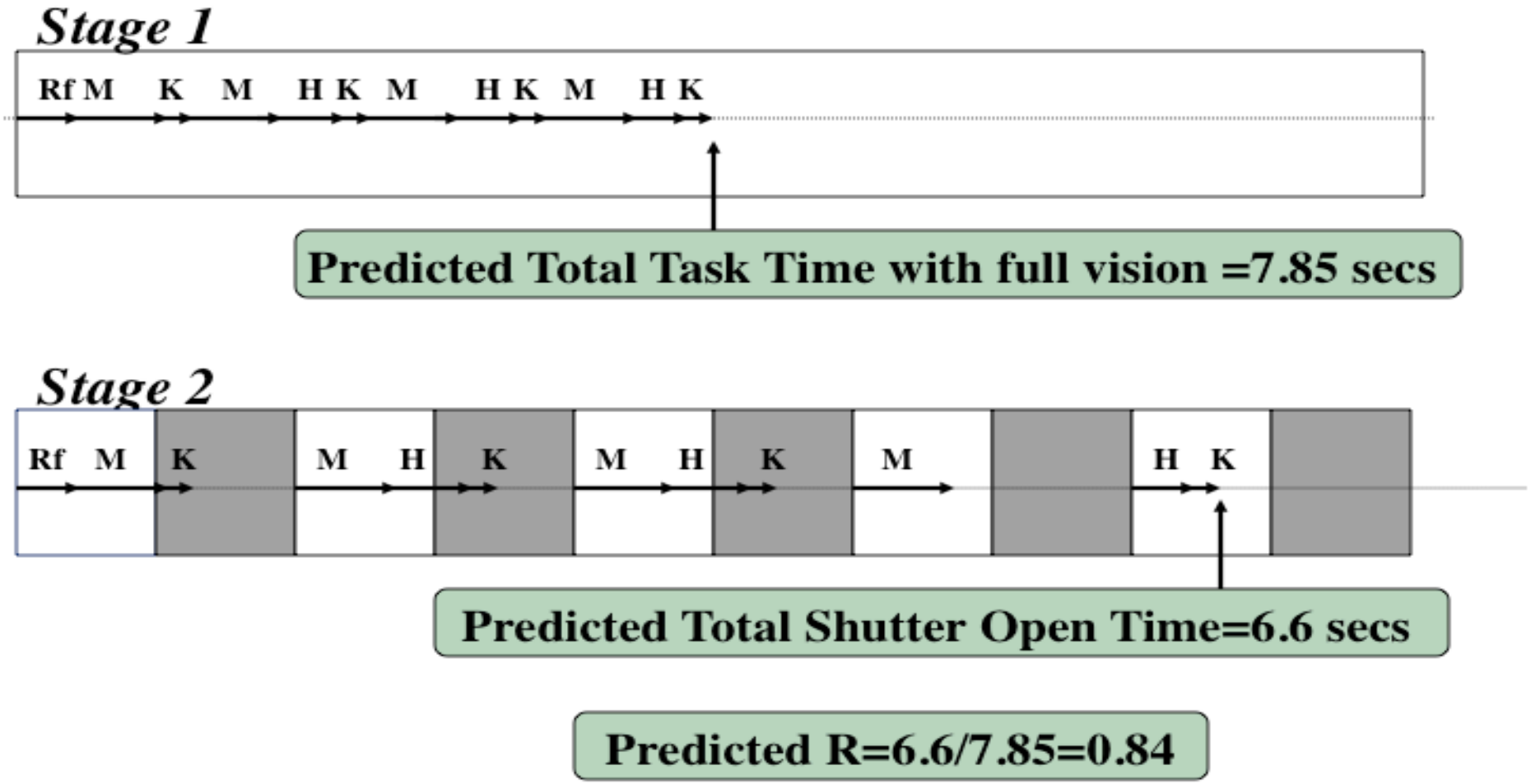
Extended KLM - Underlying assumptions

- **Assumption 1:** During 1.5 second periods of vision the operator sequence can progress without interruption
- **Assumption 2**: An operator that begins in a period of vision *can* continue into an occluded period *providing* it is not specifically associated with vision
- **Assumption 3**: An operator can *only* begin in an occluded period when vision is not required at any point in its duration

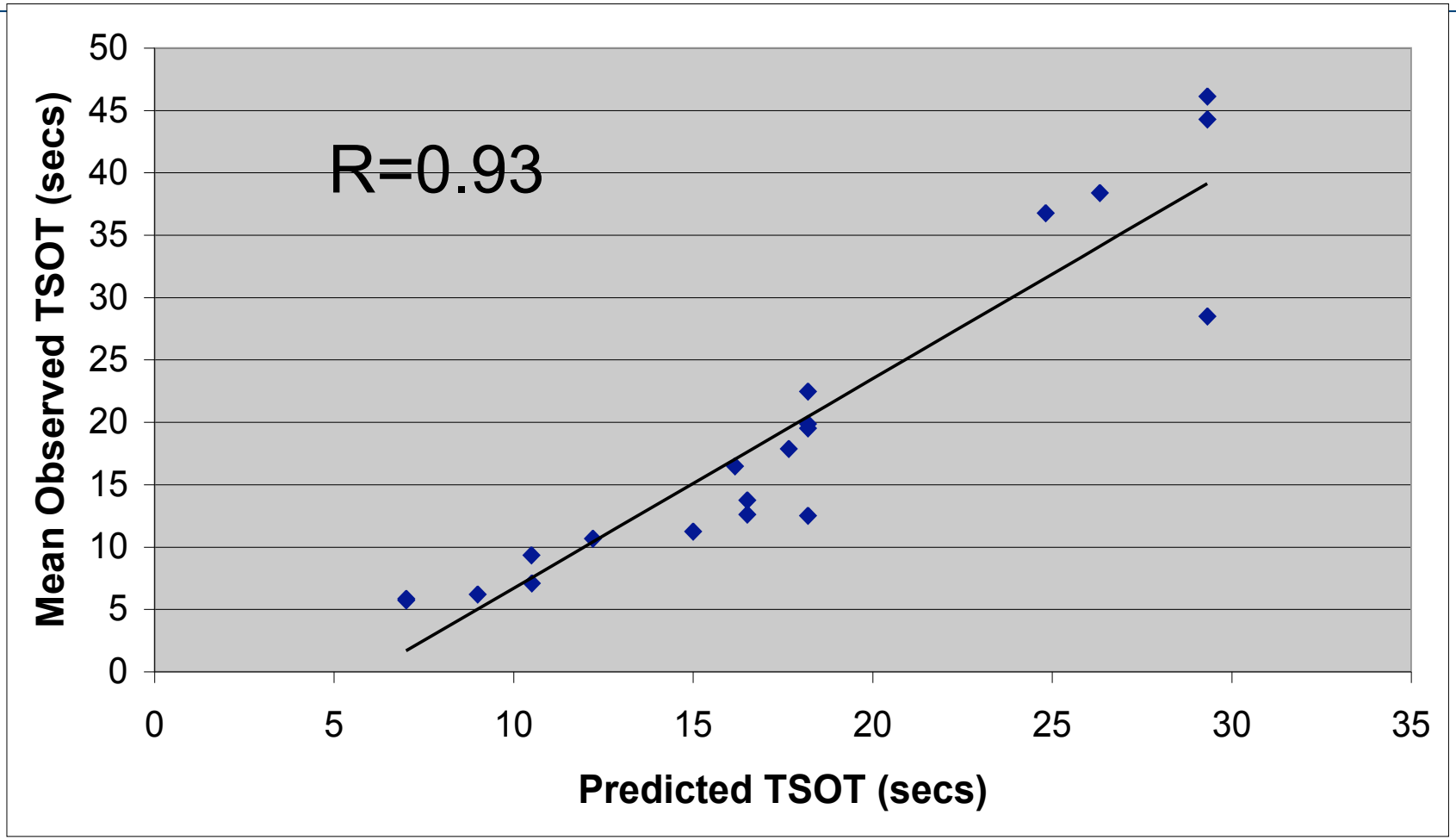
Example of an extended KLM-sound manipulation task



Example of an extended KLM-POI search



Some validity results - Observed and predicted TSOTs



Reliability of extended KLM

- Can different people use the method independently and yield similar results (inter-analyst reliability)?

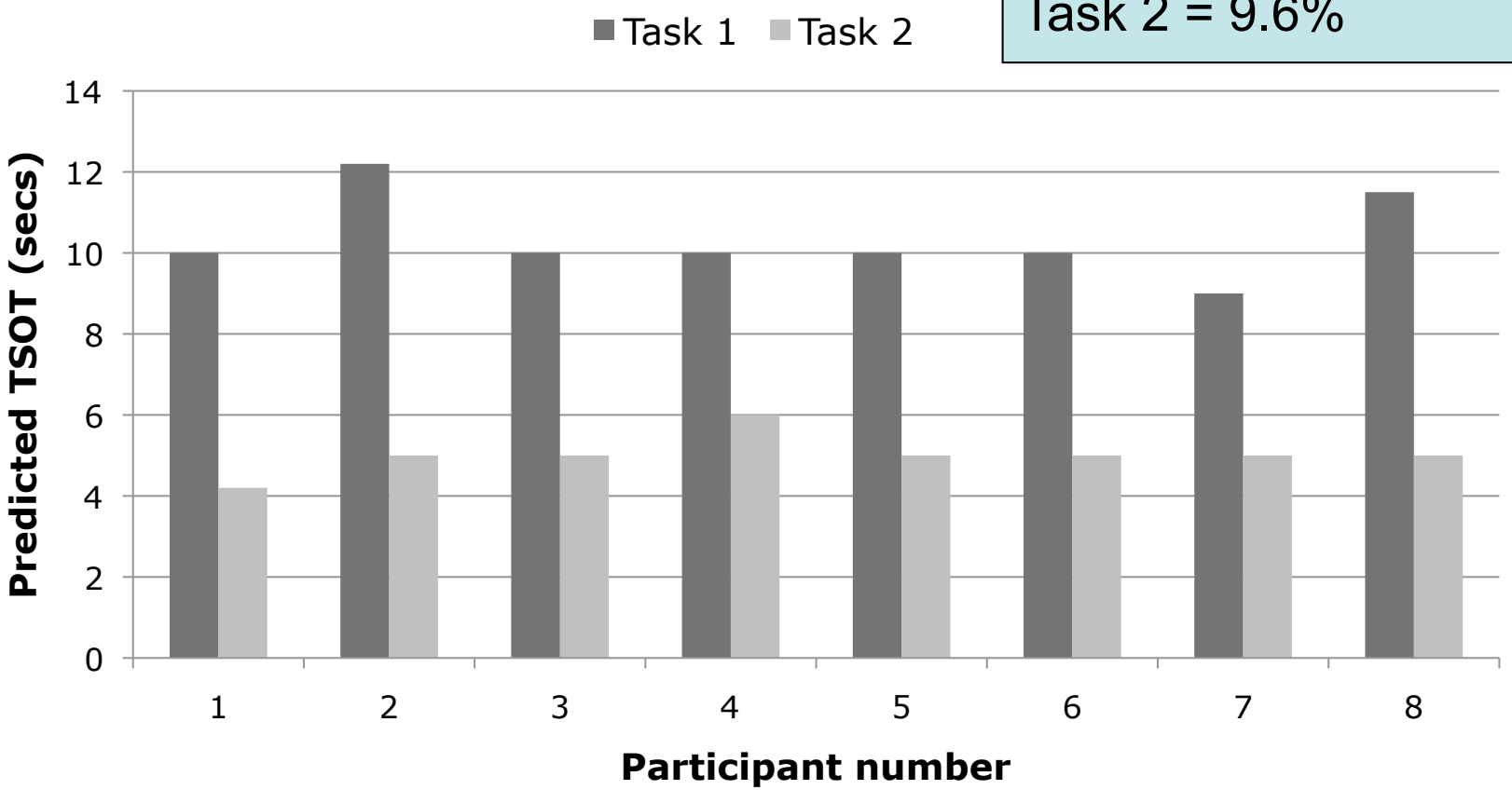
- Traditional KLM has been shown to have good reliability (e.g. Manes, Green & Hunter, 1998; Stanton & Young, 2001)
- Additional subjectivity in assumptions of extended KLM – need to consider if analysts apply the assumptions in a consistent fashion

Reliability study

- Eight Human Factors researchers independently made extended KLM predictions for two tasks:
  - Dialling a 10 digit number using a mobile phone
  - Changing the sound characteristics for an in-vehicle audio system
- All participants:
  - had experienced formal training in KLM at the University
  - were trained in the occlusion method and the use of extended KLM assumptions
- All participants given a list of fundamental operators and look-up times
- "Think-aloud" protocol used to investigate what participants were doing, and assumptions being applied

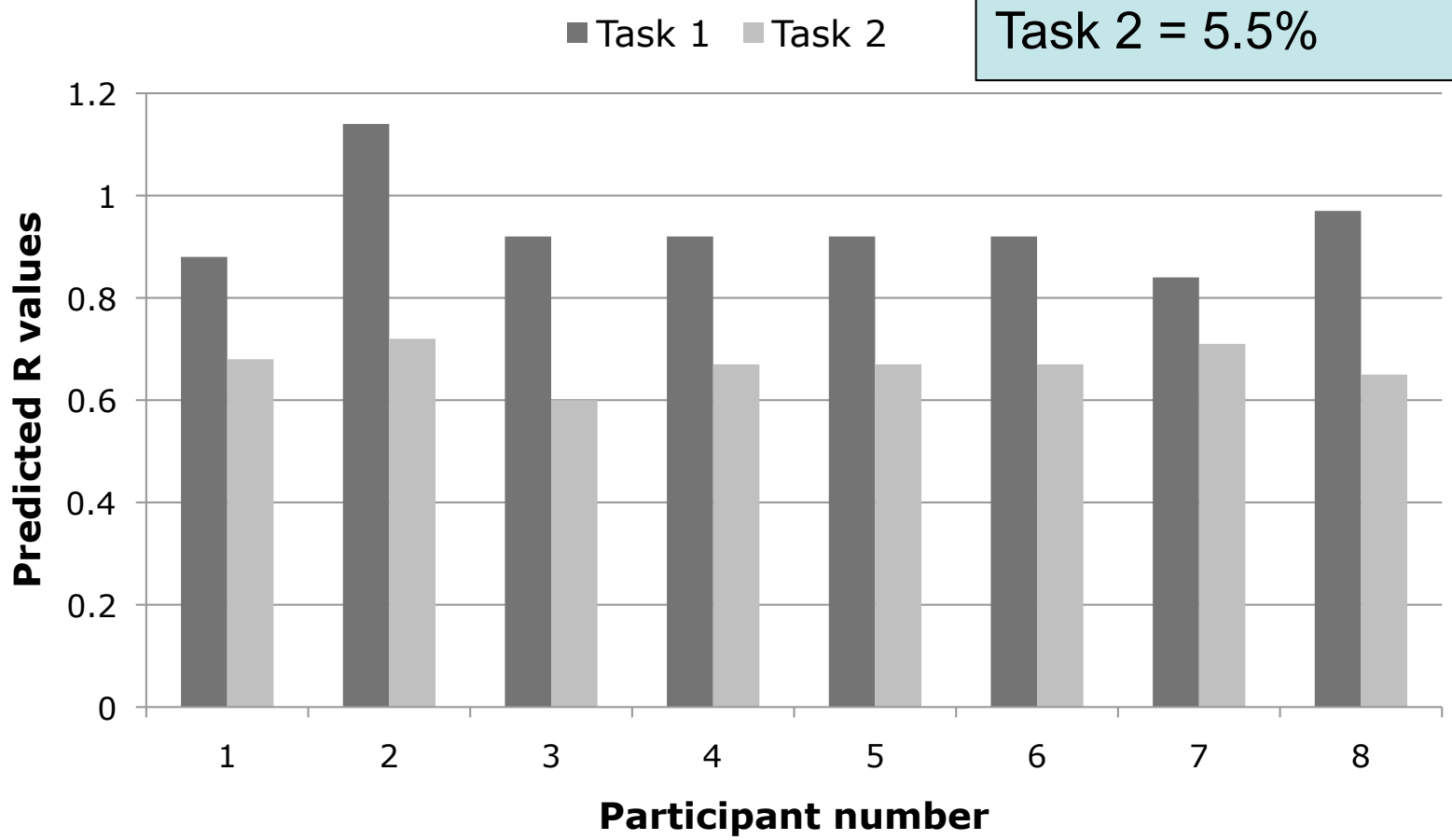
Reliability study – Results TSOT

Coefficient of Variation:
Task 1 = 9.8%
Task 2 = 9.6%



Reliability study – Results R

Coefficient of Variation:
Task 1 = 9.5%
Task 2 = 5.5%



Consistent vs inconsistent use of operators

Operator name	Total number of times used	Number of times applied consistently	Number of times applied inconsistently
Reach far (Rf)	16	14	2
Homing (H)	109	104	5
Keypress (K)	108	102	6
Mental operation (M)	32	32	0
TOTALS	265	251	14

Reliability study – Discussion points

- Inter-analyst reliability generally high
- Majority of issues related to use of traditional KLM
- Some inconsistencies arose for following operators:
  - Reach far – is vision needed when initially locating IVIS control?
  - Homing – is vision needed when moving hand between specific controls on IVIS?
  - Keypress – is vision needed when pressing specific IVIS controls?

Overall conclusions

- Extended KLM provides means for predicting visual demand of IVIS interfaces:
  - Quick/cheap
  - Can be used very early in design with lo-fi prototypes
  - Added value from analysing tasks/interfaces at this level

- Studies have shown good validity and inter-analyst reliability for the method
  - Strong predictions for TSOT and R metrics
  - Few differences in application of extended KLM assumptions across analysts

Future developments of extended KLM

- Scope
  - Studies to develop new operators and assumptions concerning more visually demanding interfaces (e.g. reading text)
- Enrichment
  - Use of extended KLM to predict new visual demand measures, e.g. “true” resumability, “blind” interaction time
- “Real-world” application
  - Software tool for encouraging practical use of method

Thank you!

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