

COGNITIVE RESILIENCE APPLIED TO STAMP

2013 STAMP Conference
Boston, Mass.
March 26-27, 2013

CONTENTS

- Introduction
- Relevance for STAMP
- Experimental studies
- Conclusion

INTRODUCTION TO COGNITIVE RESISTANCE



COGNITIVE RESISTANCE

Definition

The capacity to endure a discrepancy between reality and activated mental schemata, despite salient cues that are essentially perceived.

Not Noah!

PERCEIVE & BELIEVE

- How many of each animal did Mozes take along in the Arc?



COGNITIVE RESISTANCE

- We ignore stimuli that do not *seem* relevant to tasks at hand
 - Saves resources
 - Improves routine operations
- Describes a (real) physiological and neurological process
 - Implicit perception
 - A lag in stimulus matching
 - Sudden explicit perception / reflection, sometimes accompanied by surprise
- Can terminate in two ways:
 - The discrepancy is brought into consciousness (i.e. reflection)
 - Reality realigns itself with the activated mental schema (i.e. the cues go away)

COGNITIVE RESISTANCE IS WELL KNOWN

Similar Phenomena

- Looking-but-not-seeing / inattentional blindness
- Cognitive Fixation
- Automation surprise
- Automation bias

Examples

- A320 mode input failure, January 20th, 1992
- Turkish Airlines crash at Amsterdam, February 25th, 2009
- Emirates 407, 20 March 2009, Melbourne Australia : A340
- Taxiway take-off, February 10th 2010

Australian Transport Safety Board. (2009).

Dutch Safety Board. (2010). *Crashed during approach, Boeing 737-800, near Amsterdam Schiphol airport, 25 February 2009.*

Dutch Safety Board. (2011). Take-off from Taxiway Amsterdam Airport Schiphol (p. 94). The Hague, the Netherlands.

Leveson, N. (2011). Engineering a safer world: Systems thinking applied to safety.

Manzey, D., & Onnasch, L. (2012). Human Performance Consequences of Automated Decision Aids : 6(1), 57–87.

Sarter, N., & Woods, D. (1995). How in the world did we ever get into that mode? Mode error and awareness in supe control. *Human Factors: 37*(1), 107–126.

Woods, D. D., Dekker, S., Johannesen, L. J., Cook, R. I., & Sarter, N. (2010). Behind human error (2nd ed.)

Sarter, N. B., Woods, D. D., & Billings, C. E. (1997). Automation surprises. *Handbook of hf and ergonomics* (Vol. 2, pp. 1826–1943).

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst : sustained inattentional blindness for dynamic events. *Perception*, 28, 1059–1074.

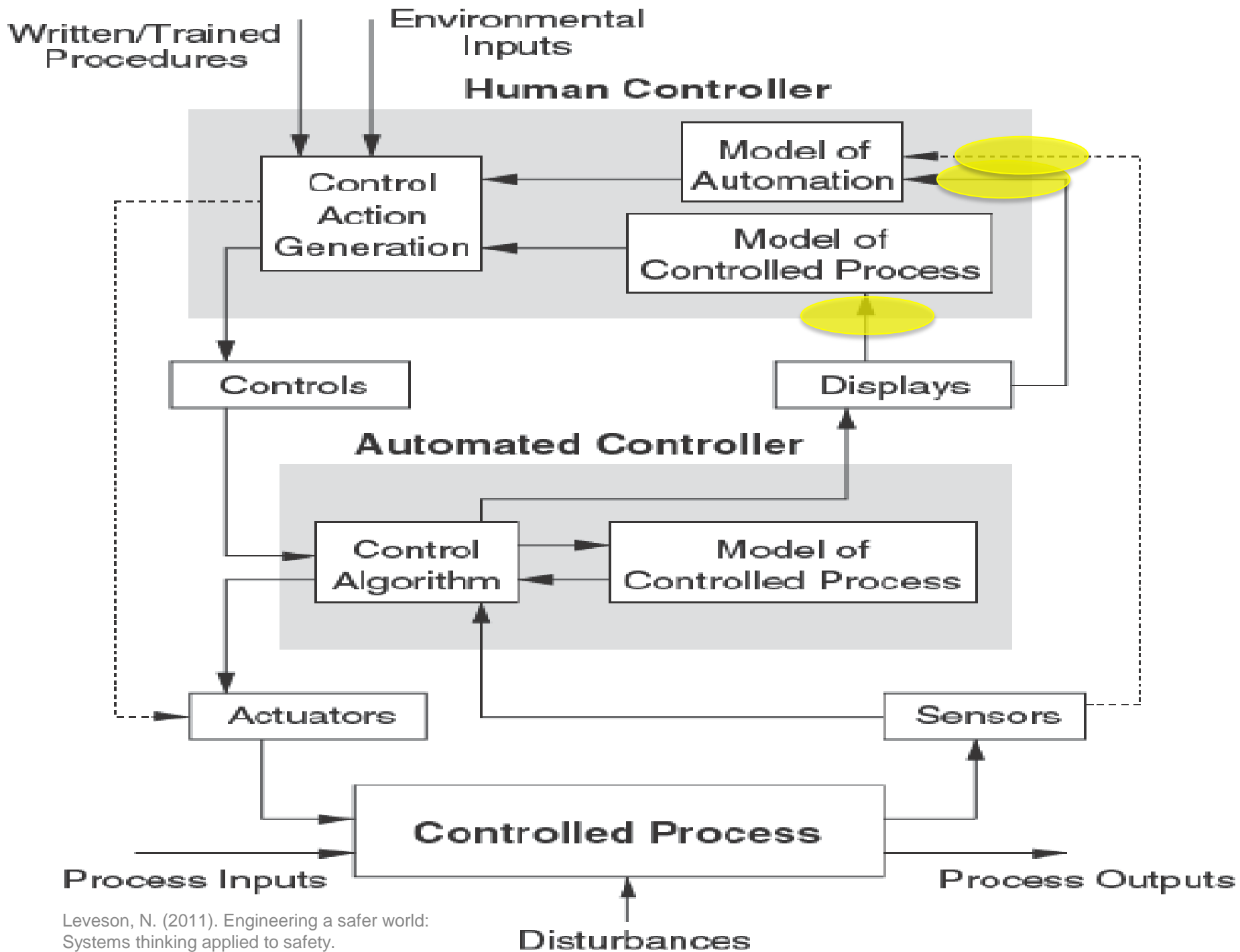
WHY A NEW CONSTRUCT?

- An epistemologically sound definition (hopefully..)
- Describes normal rather than erroneous human behavior
- Focuses on the episodic nature of the phenomenon

RELEVANCE TO STAMP

www.international.hva.nl

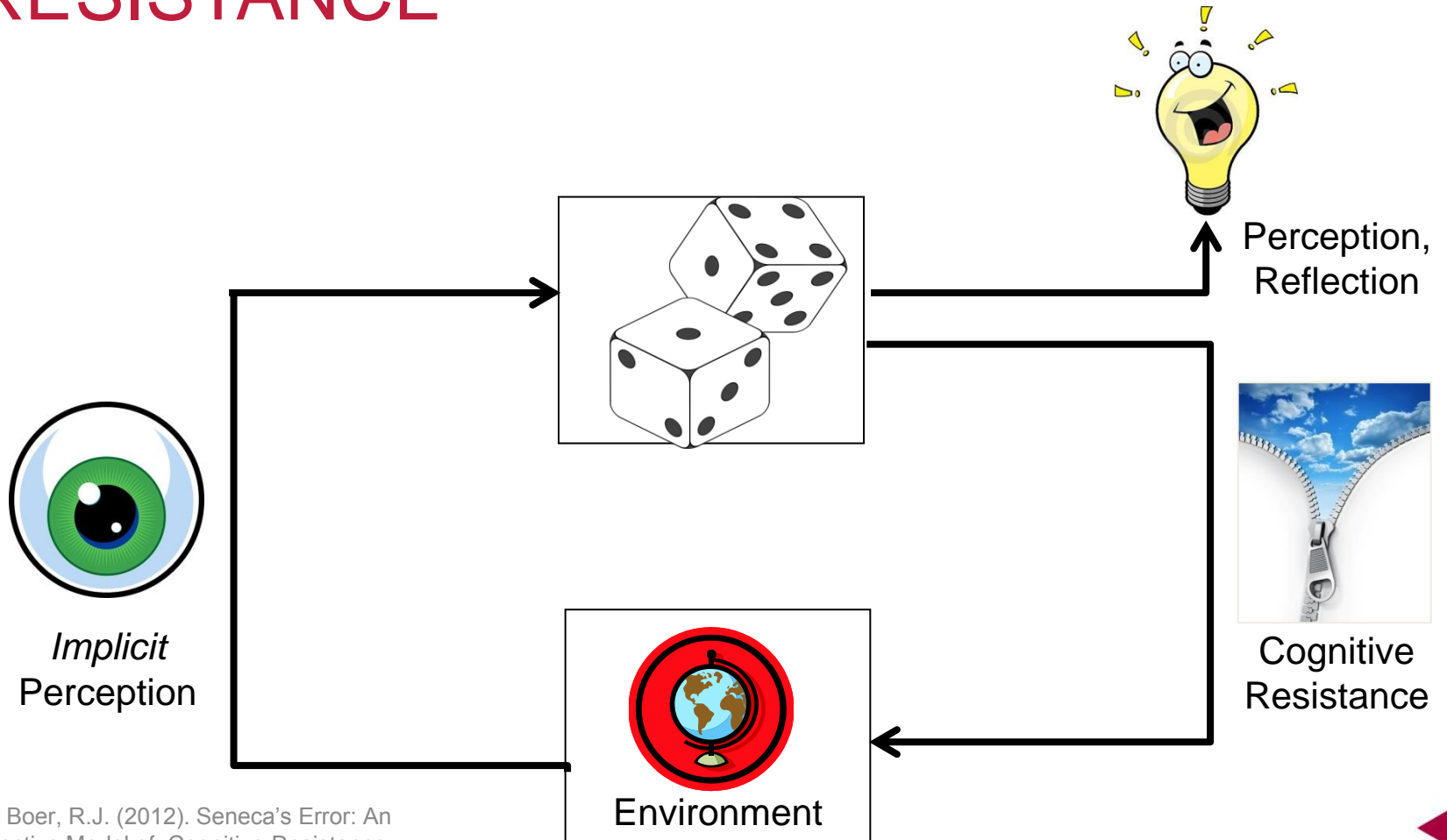




RECENT CRITICISM OF HUMAN FACTOR IN STAMP

“The human factors element of STAMP is somewhat limited and under-specified. Human error is conceptualised as essentially a failure of the operator’s mental model of the system [...]. The model of human behaviour implicit in STAMP is somewhat deterministic. “

STOCHASTIC MODEL OF COGNITIVE RESISTANCE

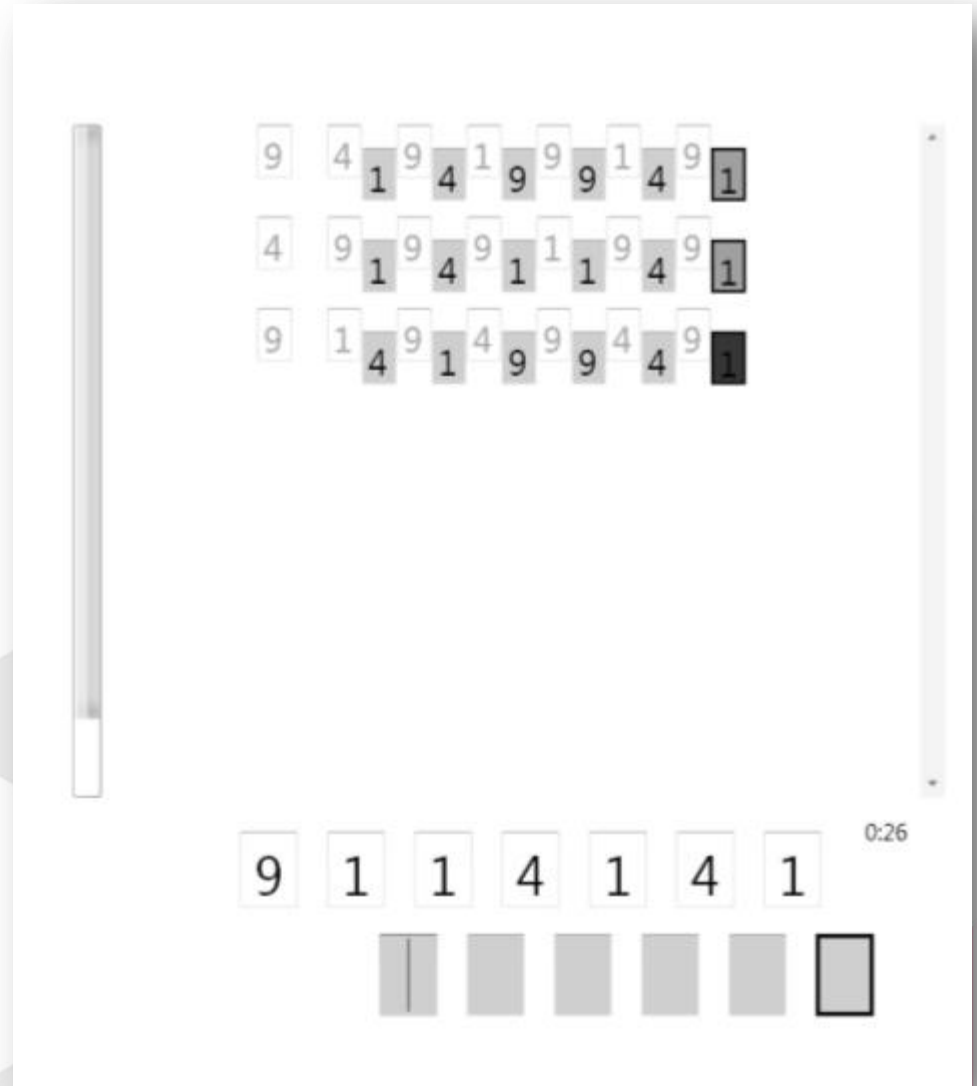


EXPERIMENTAL STUDY



EXPERIMENT

- Number Reduction Task
 - 2 rules
 - Time and error limit
- 81 participants
 - Professional engineers
 - Engineering students
- Manipulation: Impossible to meet the task objective while applying the learned rules

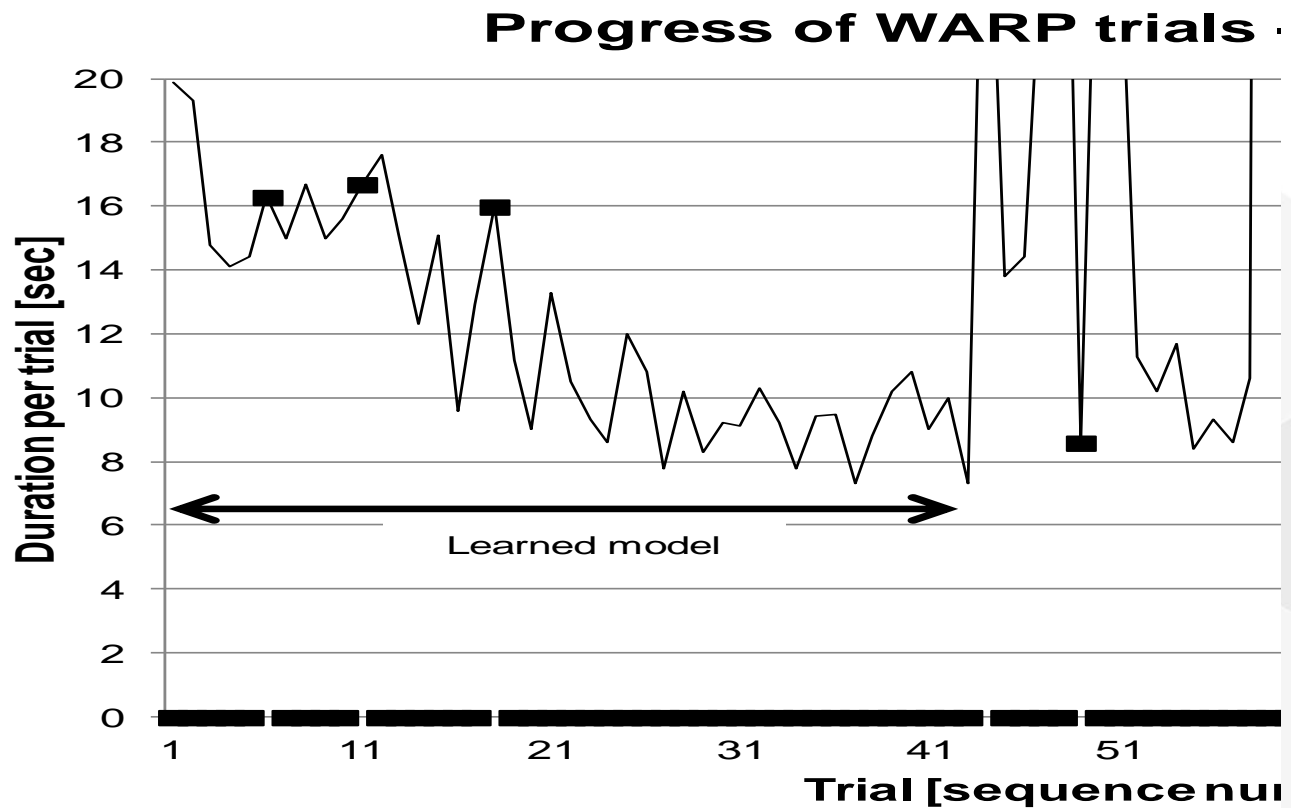


The screenshot displays a digital interface for a Number Reduction Task. At the top, there is a 3x10 grid of numbers. The numbers are arranged as follows:

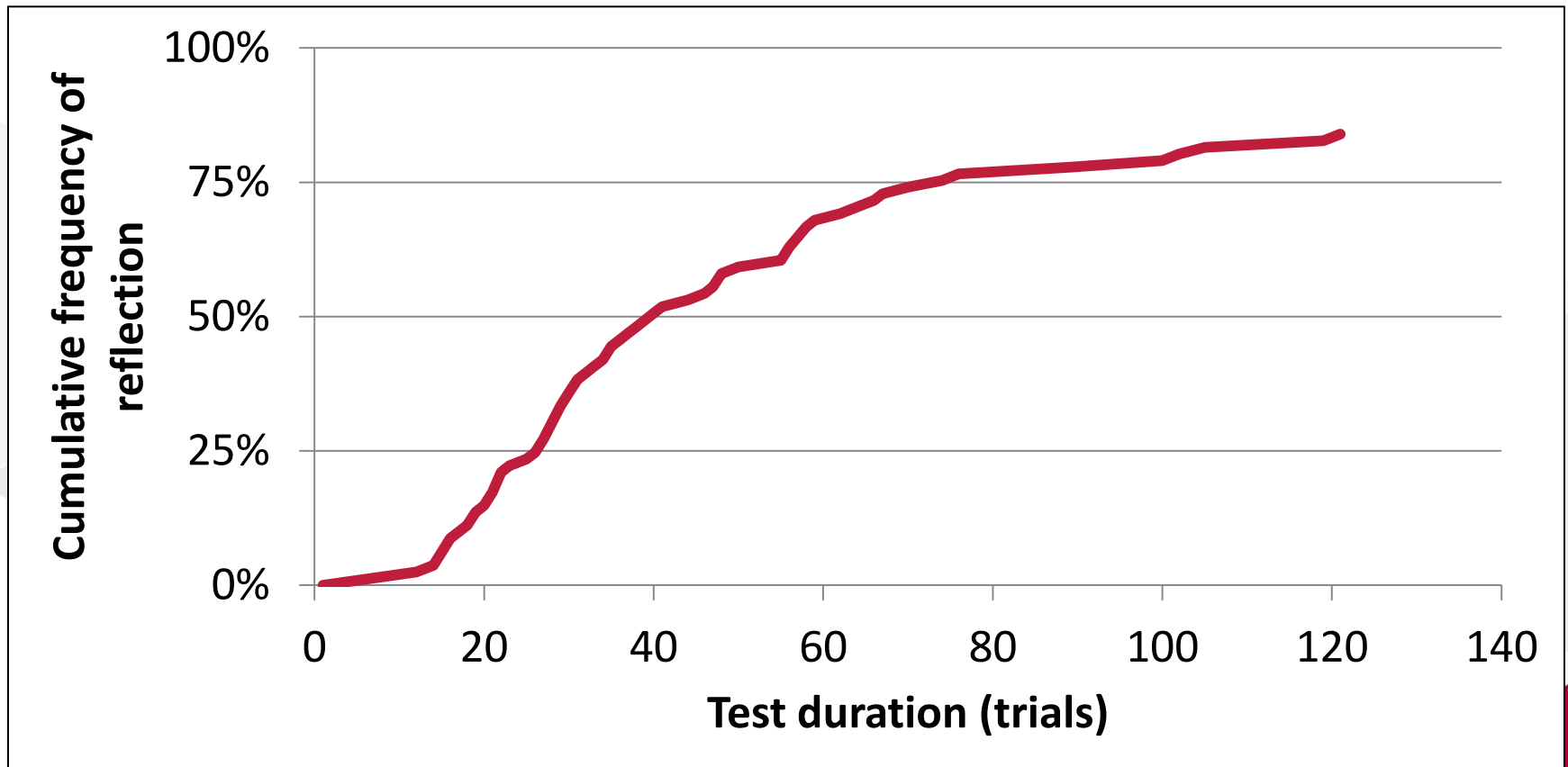
| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | 4 | 1 | 9 | 4 | 1 | 9 | 9 | 1 | 4 | 9 | 1 |
| 4 | 9 | 1 | 9 | 4 | 9 | 1 | 1 | 9 | 4 | 9 | 1 |
| 9 | 1 | 4 | 9 | 1 | 4 | 9 | 9 | 4 | 4 | 9 | 1 |

Below the grid, there is a single row of numbers: 9, 1, 1, 4, 1, 4, 1. To the right of this row is a timer showing 0:26. Below the numbers is a row of seven empty boxes, each with a vertical line on the left side, representing a stack or a list of numbers to be reduced.

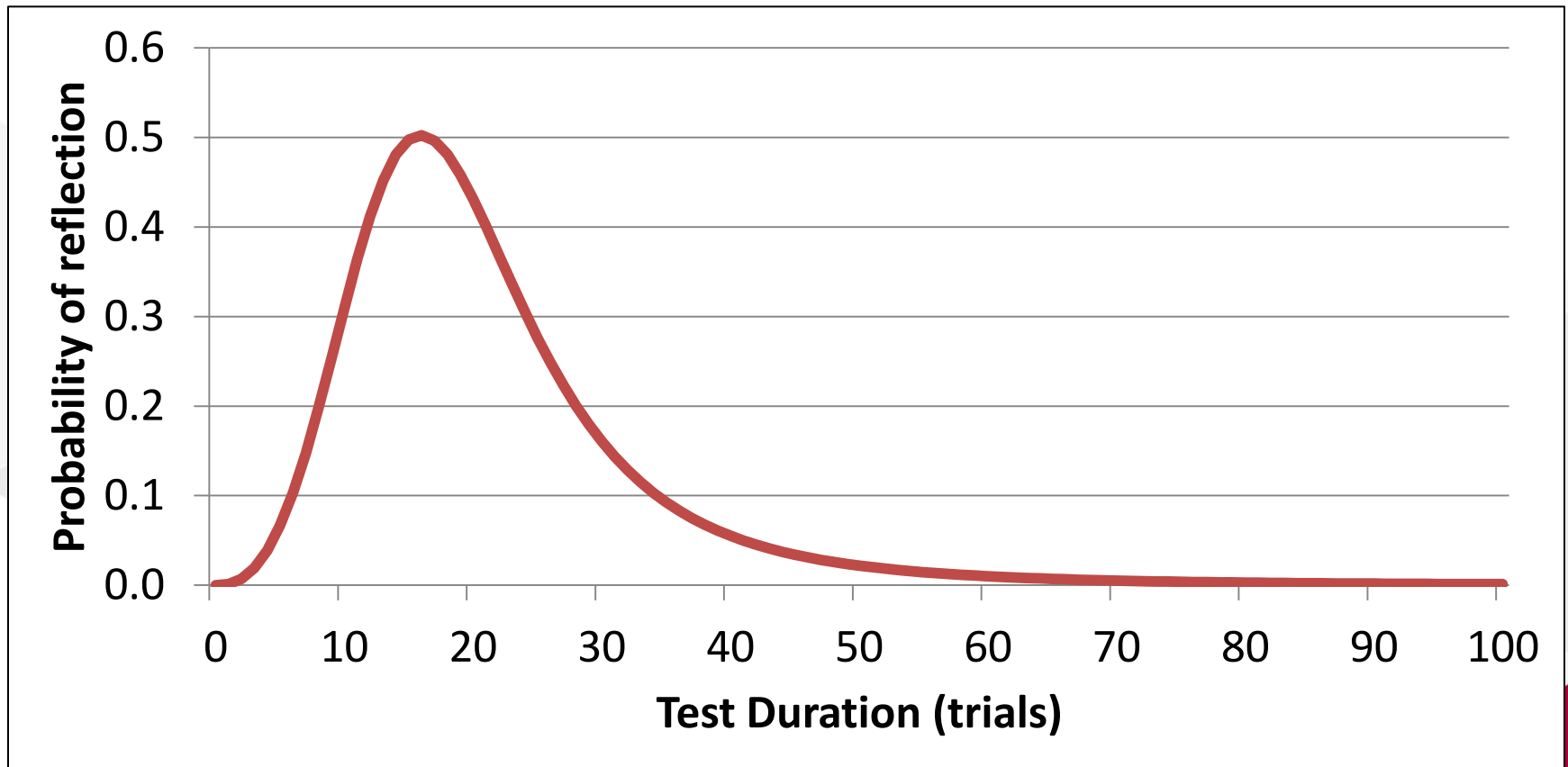
TYPICAL RUN



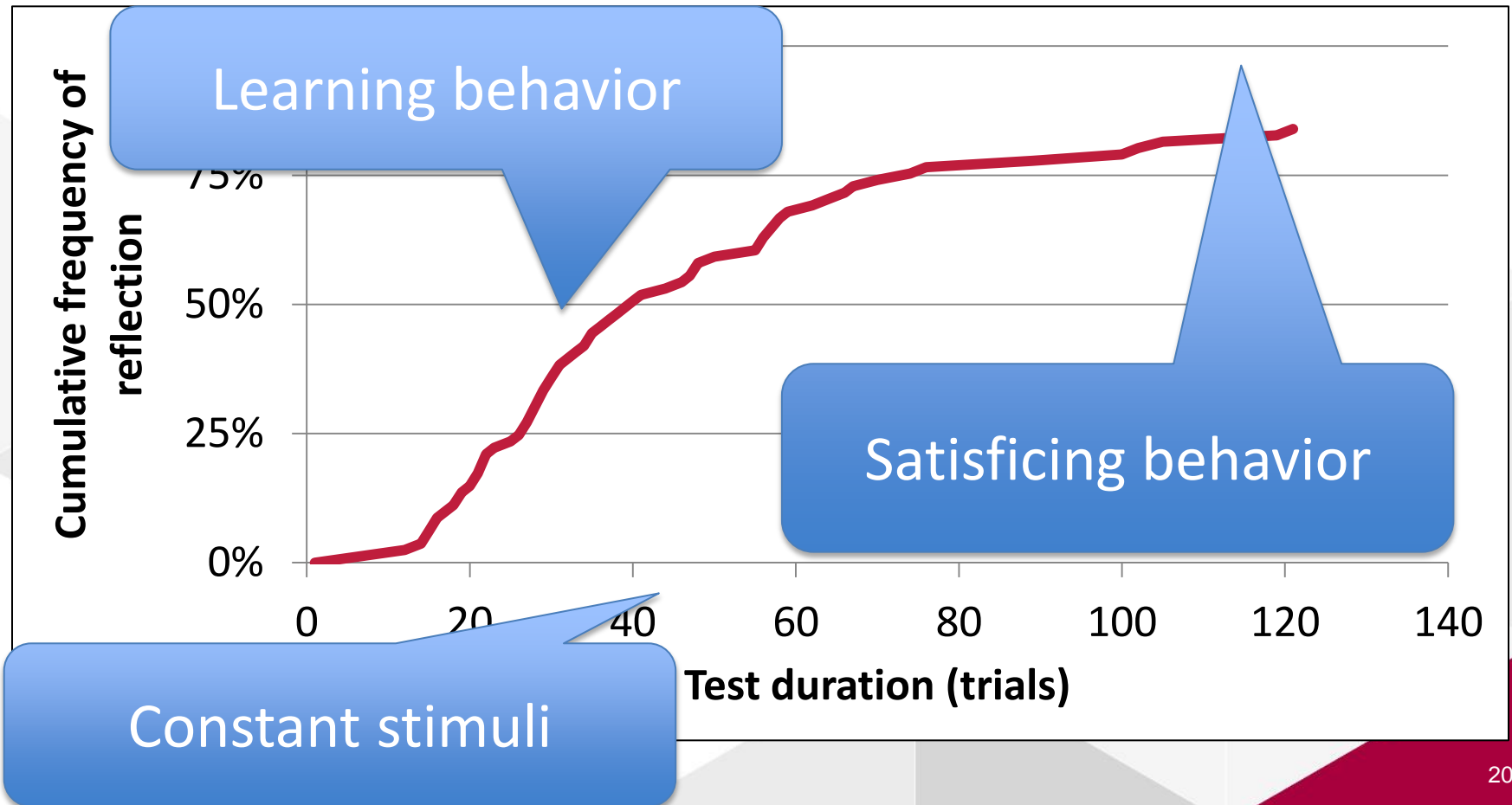
EXPERIMENTAL RESULTS (N=81)



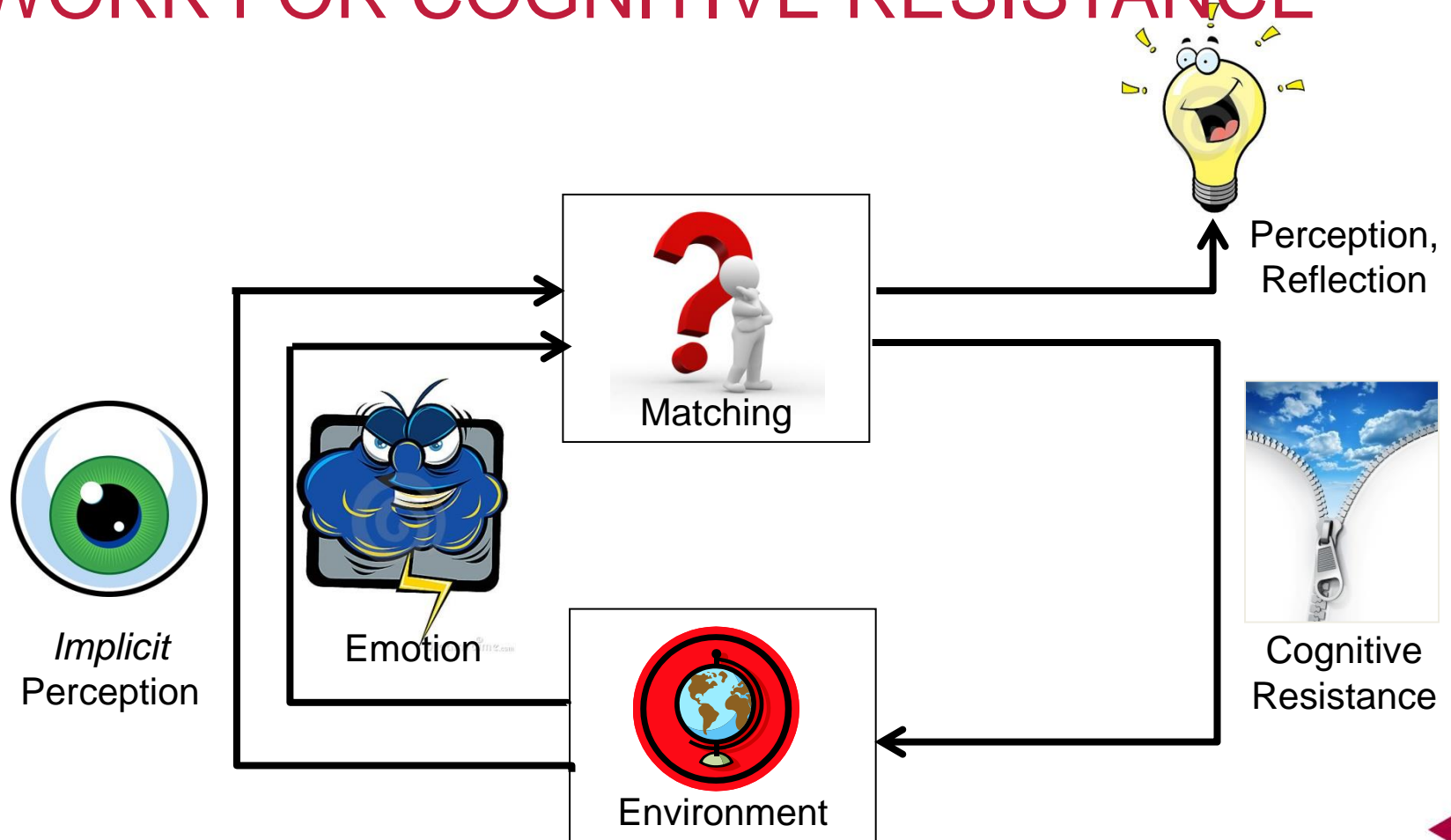
UNIMODAL LOG-LOGISTIC DISTRIBUTION OF COGNITIVE RESISTANCE



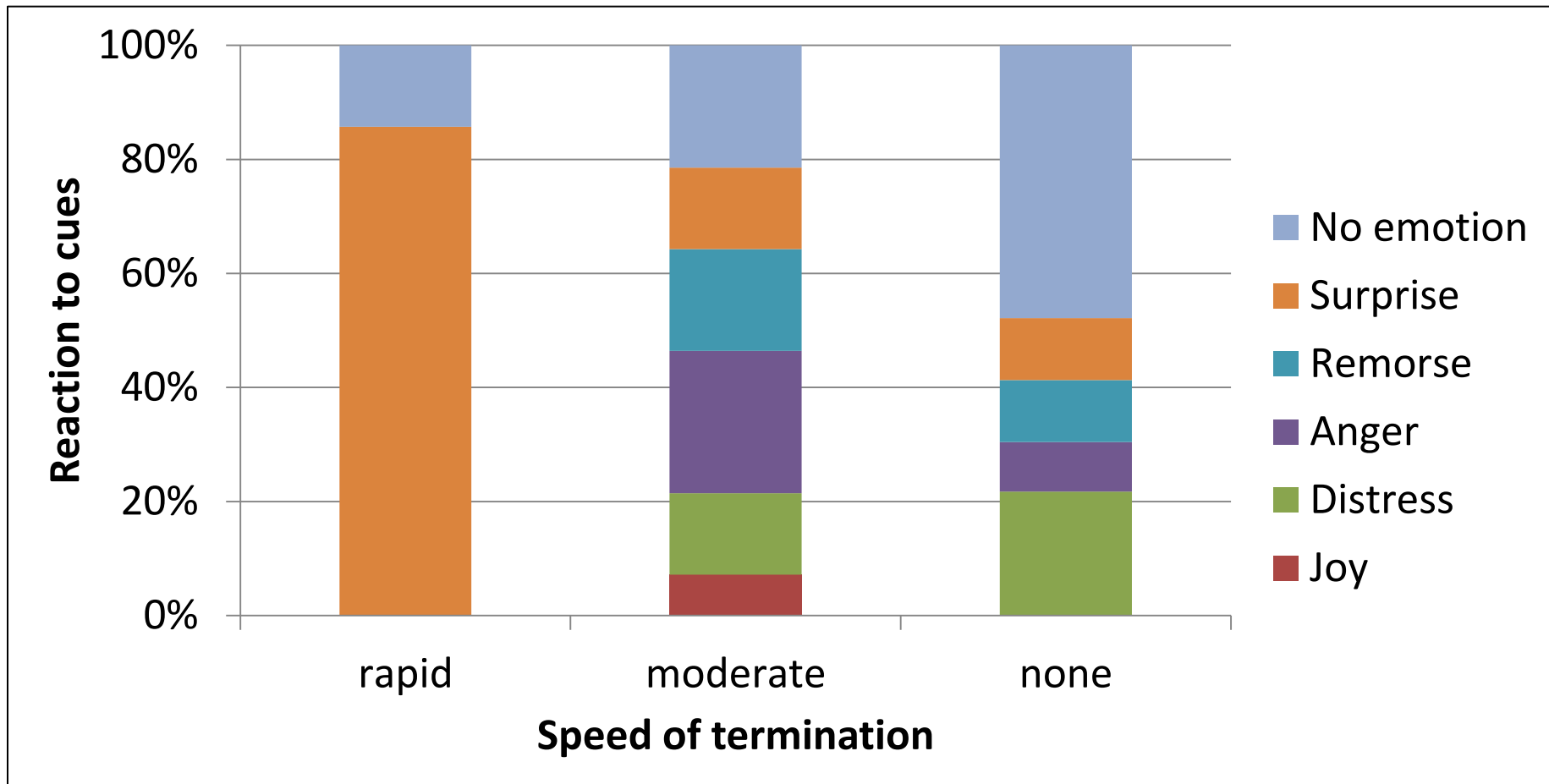
EXPERIMENTAL RESULTS



REINFORCEMENT LEARNING FRAME- WORK FOR COGNITIVE RESISTANCE



EFFECT OF EMOTION ON TERMINATION RATE OF COGNITIVE RESISTANCE



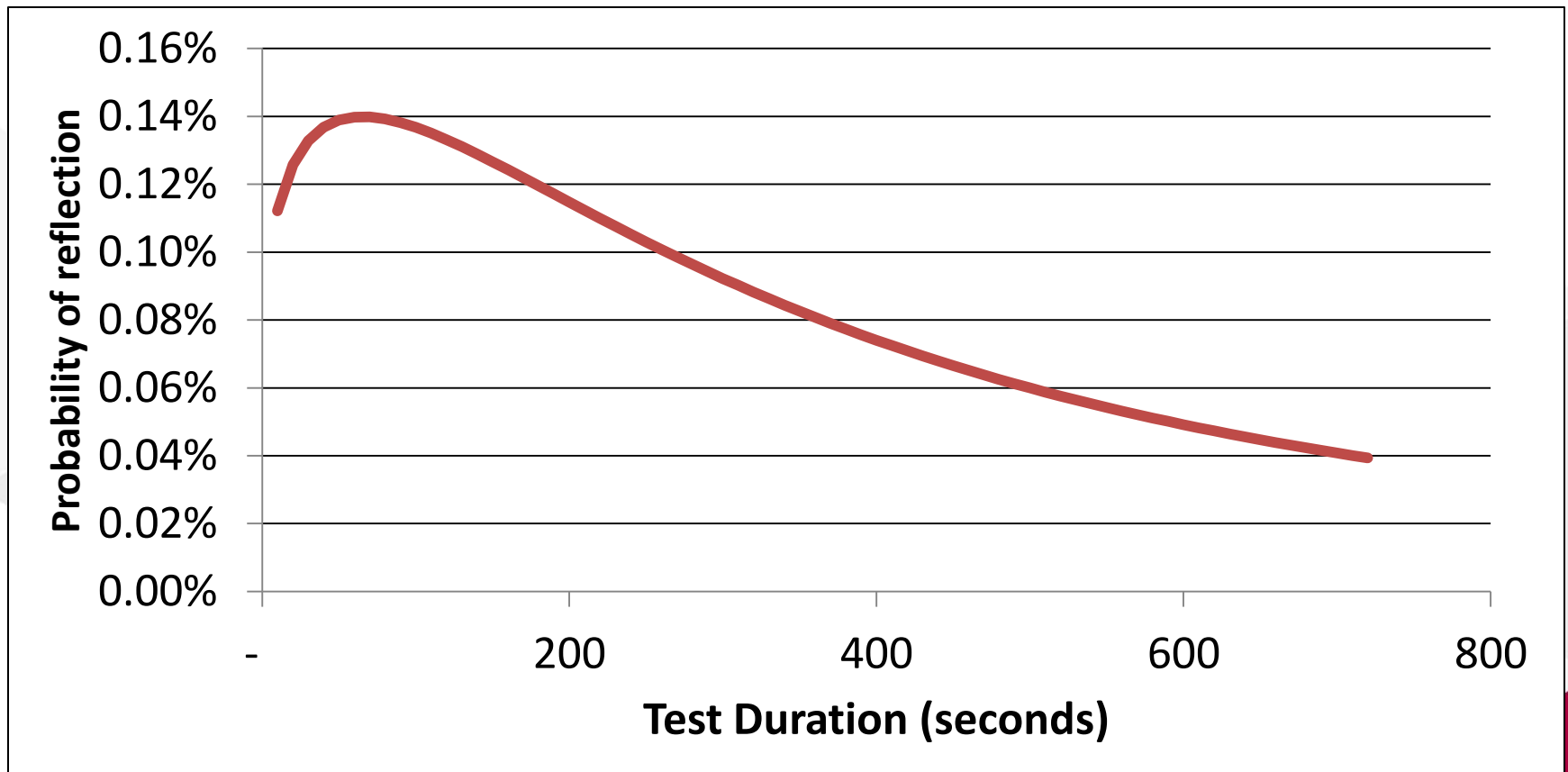
REPEAT IN MORE PRACTICAL SETTING



Thrust lever malfunction: cues

- N1 axis speed indications
- Exhaust gas temperature
- N2 rotation speed
- Fuel flow
- Rudder deflection
- 6 cues on ECAM page
 - Fuel consumed (2x)
 - Oil pressure
 - Vibrations,
 - Oil quantity,
 - Remaining fuel.
- **But not on ECAM**

LOG-LOG DISTRIBUTION OF COGNITIVE RESISTANCE – SIM RESULTS (N=27)



CONCLUSION



CONCLUSION – VALUE OF COGNITIVE RESISTANCE FOR STAMP

- Cognitive Resistance describes human perception performance
 - Stochastic with known probability distribution (unimodal log-logistic)
 - Learning or satisficing process
 - Emotions as reward / penalty mechanism
- Contribution to STAMP
 - Normal rather than erroneous performance
 - Stochastic rather than deterministic

THANK YOU FOR YOUR ATTENTION

Robert J. de Boer, rj.de.boer@hva.nl

Website: <http://www.hva.nl/kenniscentrum-dt/onderzoeksthema/aviation/>

www.international.hva.nl



CONTROL FLAWS

- Inadequate control actions
 - Unidentified hazards
 - Inappropriate etc. control actions
 - Design of control process do not enforce constraints
 - Inconsistent etc. process models
 - Inadequate coordination
- Inadequate execution of control action
 - Communication flaw
 - Inadequate actuator (operator) operation
 - Time lag
- Inadequate or missing feedback
 - Not provided in system design
 - Communication flaw
 - Time lag
 - Inadequate sensor operation

MEASURING COGNITIVE RESISTANCE

Situational Awareness (SAGAT)

- Aircraft state
- Flight path
- Traffic
- Terrain
- Weather
- ...

Automation Awareness (AAGAT)

- Equipment state
- Normal / alternate law
- Operational mode
- ...