HRA Data on Basic Identification Tasks: Results from Two Experiments

NRC's HRA Data workshop

15-16 March, 2018 – Washington DC, USA

Salvatore Massaiu

Senior Research Scientist

OECD Halden Reactor Project – Institute for Energy Technology

Ideal HRA data

Actuarial data on the tasks performed by NPP personnel

Human error probabilities = Error relative frequencies

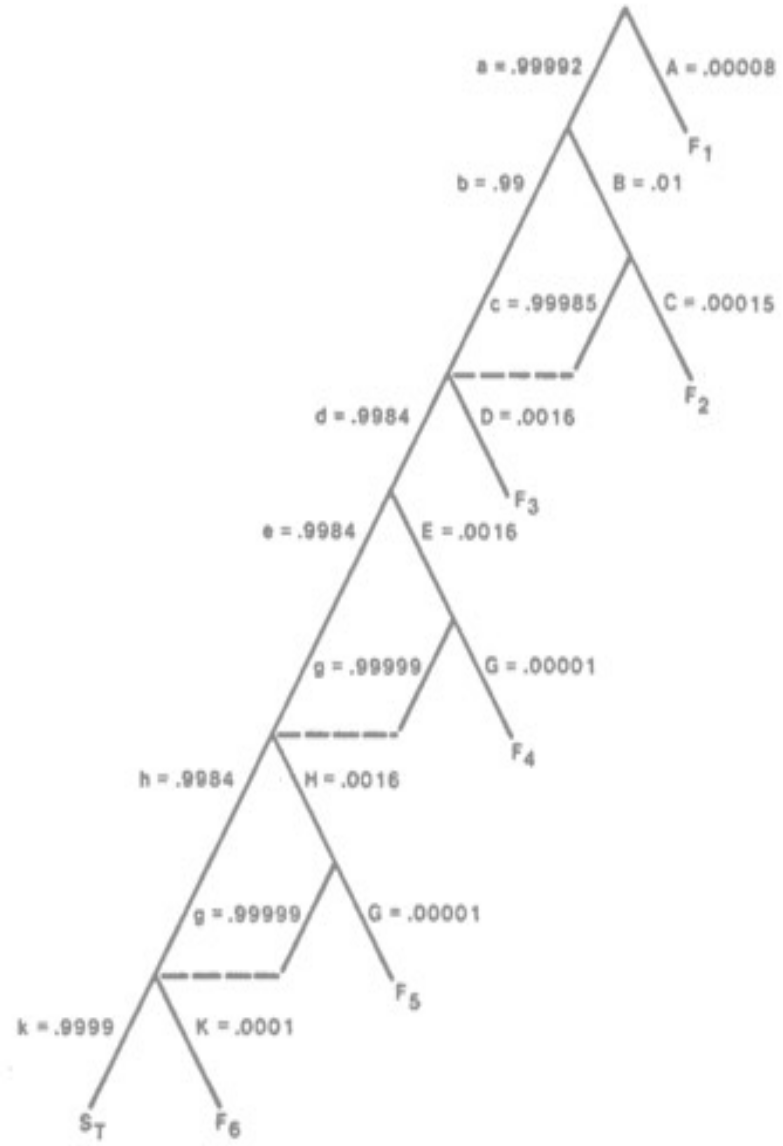
$$\frac{\text{number of times an error has occurred}}{\text{number of opportunities for an error to occur}}$$

Decompositional approach

Our general approach is to

1. divide human behavior … into small units,
2. find data (…) that fit these subdivisions and then
3. recombine them to derive estimates of error probabilities

Swain, 1983



Basic tasks in reading unannunciated quantitative info

Table 20-10 Estimated HEPs for errors of commission in reading and recording quantitative information from unannunciated displays (from Table 11-3)

Item	Display or Task	HEP*	EF
(1)	Analog meter	.003	3
(2)	Digital readout (< 4 digits)	.001	3
(3)	Chart recorder	.006	3
(4)	Printing recorder with large number of parameters	.05	5
(5)	Graphs	.01	3
(6)	Values from indicator lamps that are used as quantitative displays	.001	3
(7)	Recognize that an instrument being read is jammed, if there are no indicators to alert the user	.1	5

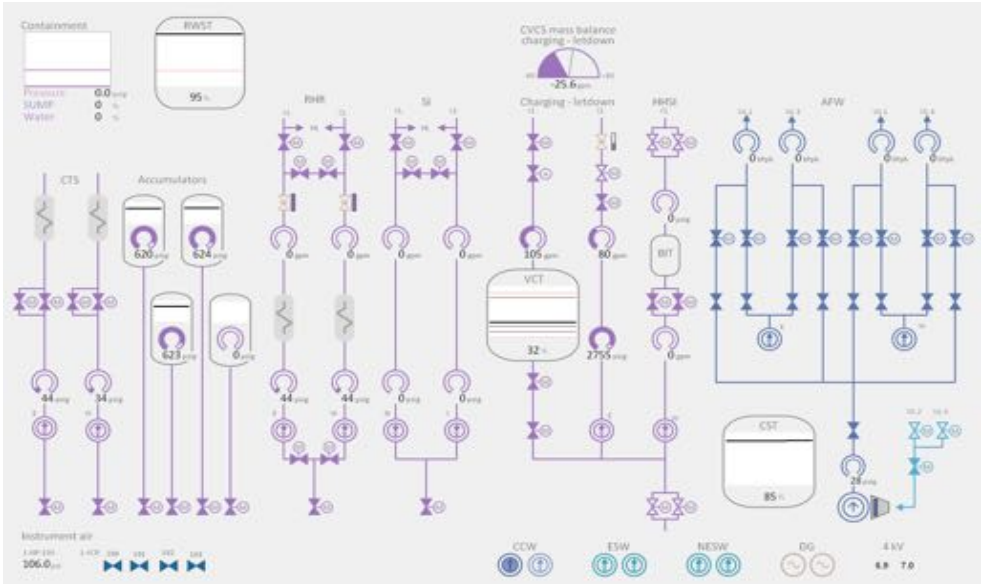
The Data Sets of this presentation

STUDY	SIMULATOR	HUMAN SYSTEM INTERFACES
2015 PWR	U.S. training simulator	Analog panels – Digital Overview Display 12” Tablet
2015 BWR	HAMMLAB	Conventional – Innovative Digital Displays 30” monitor 30” monitor

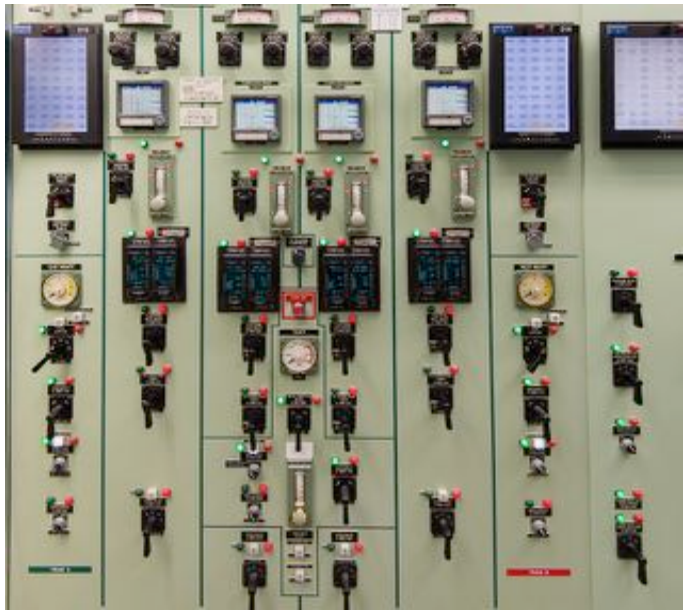
ANALOG PANELS

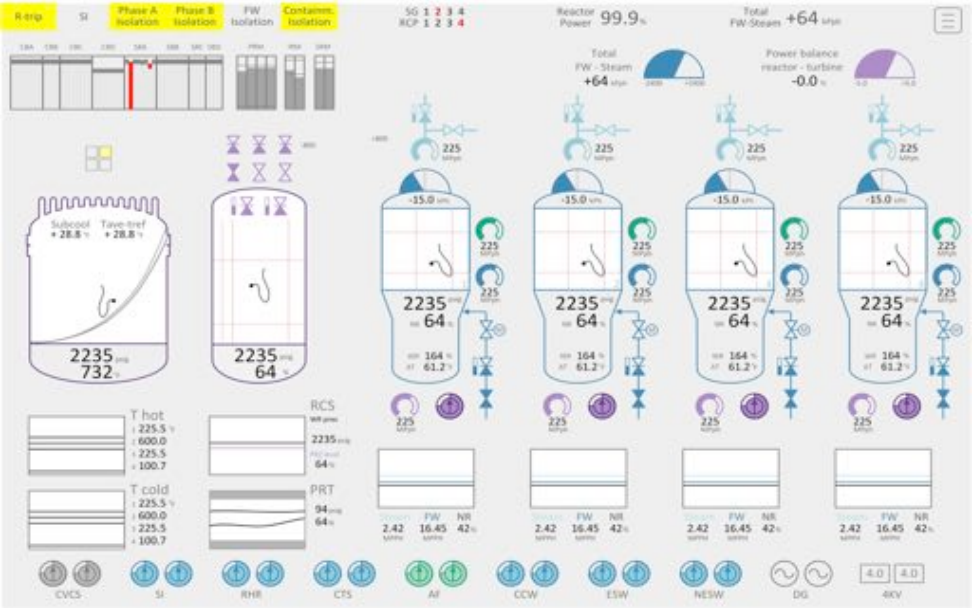
DIGITAL HSI

ECCS

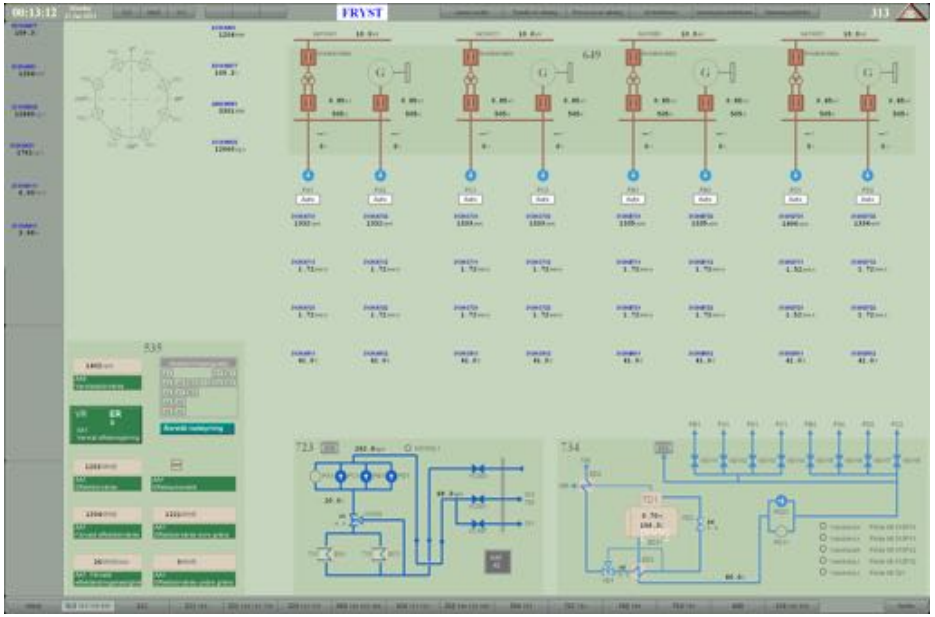


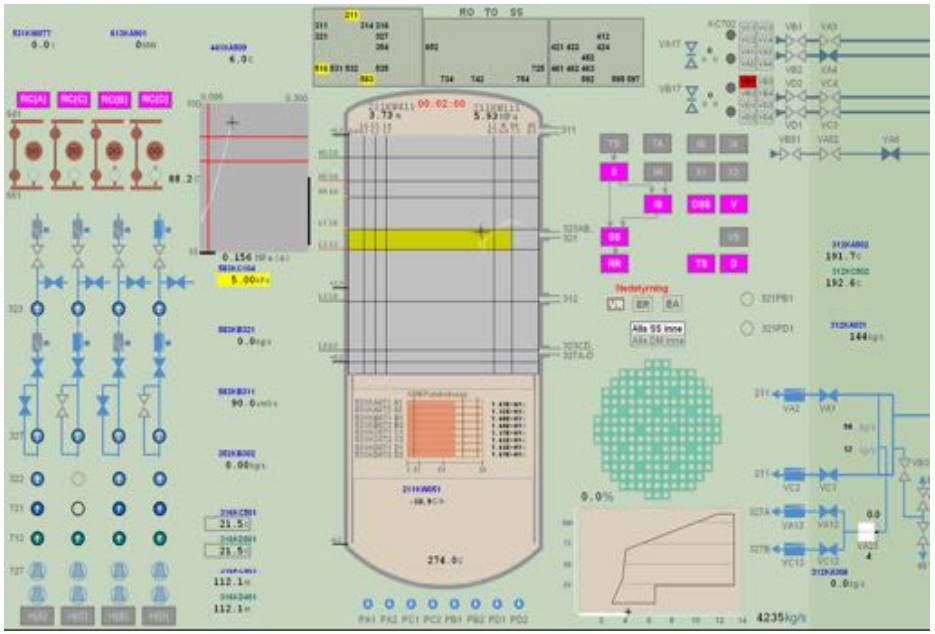
RCS



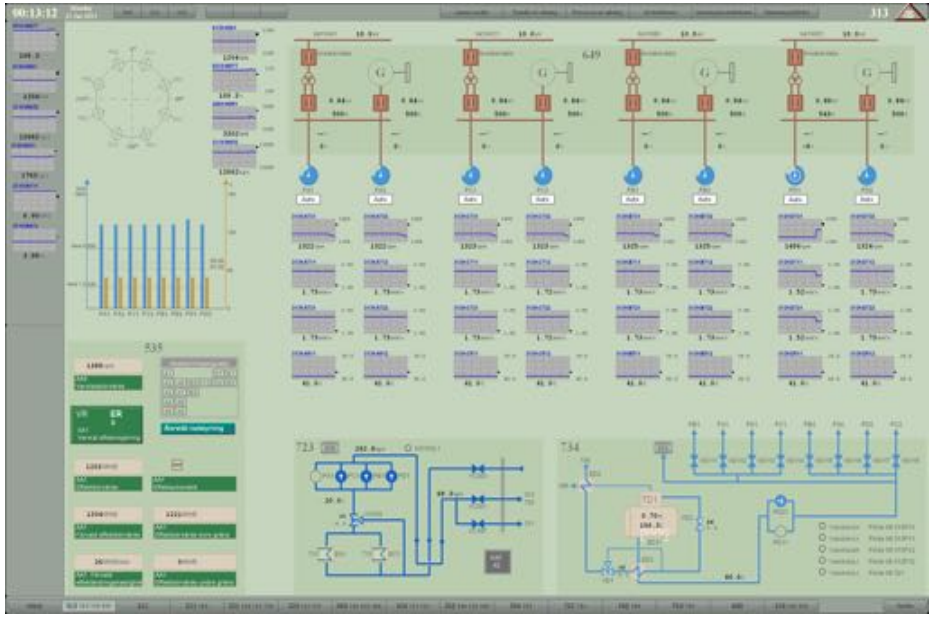


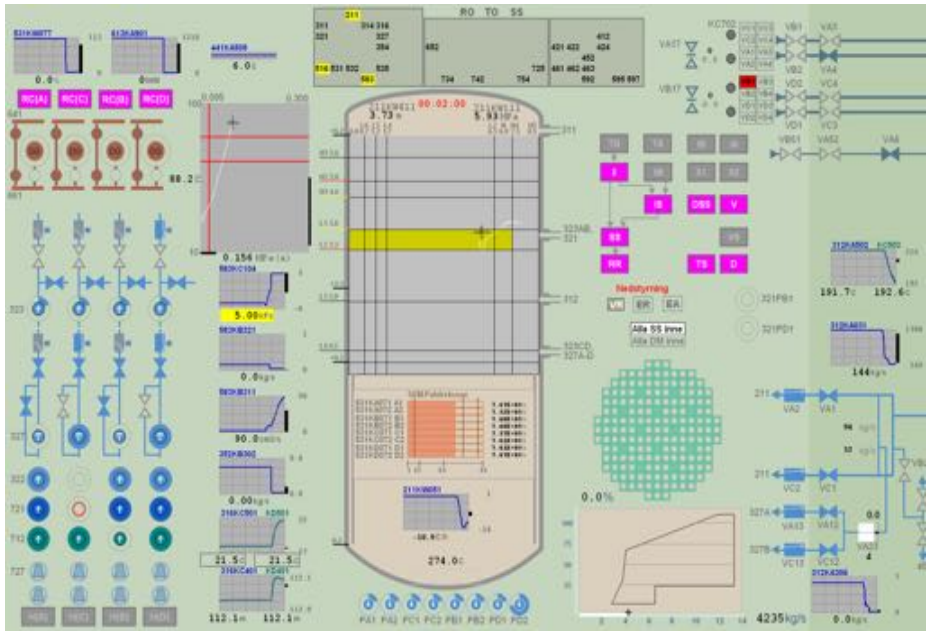
Conventional Displays





Innovative Displays





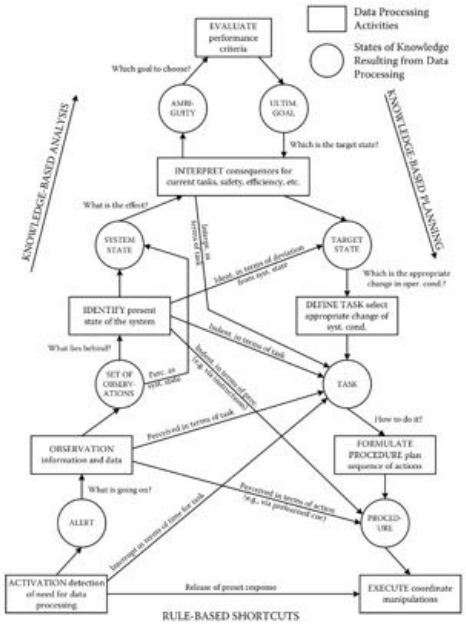
Research question

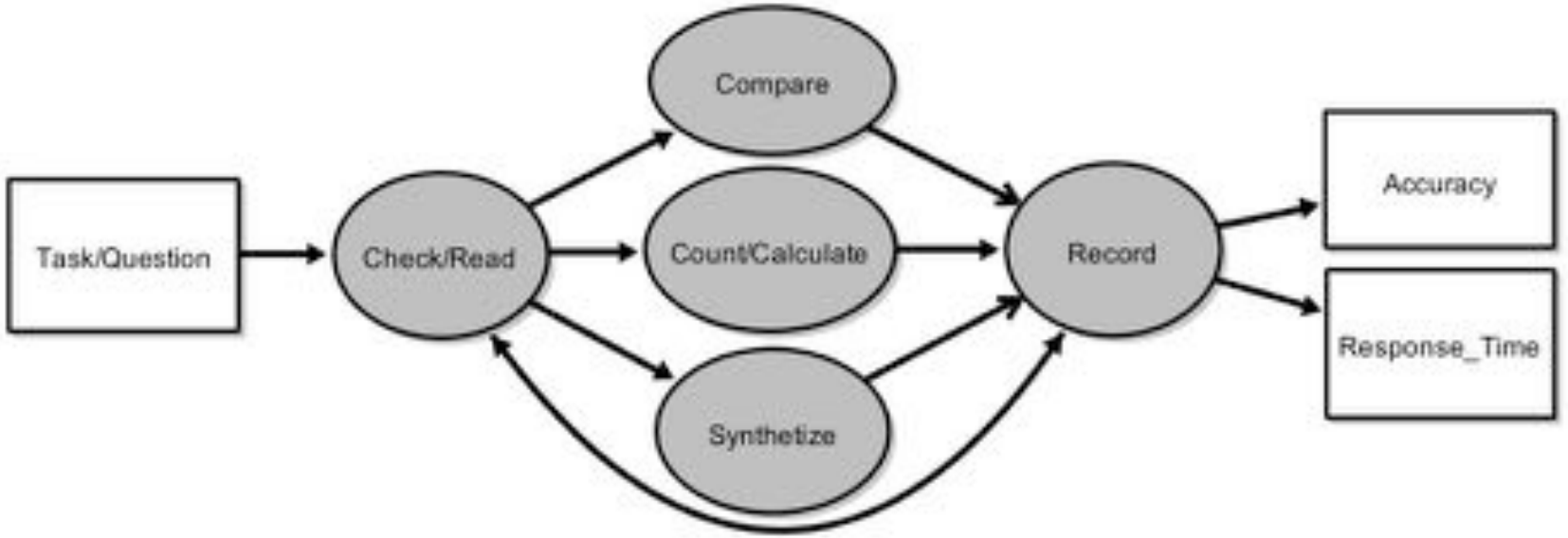
Is the **cognitive task type** important to operator reliability of identification tasks?

Identification tasks

In Cognitive Systems Engineering identification is defined as:

Decision making sub-tasks in which information is acquired from the HSI and processed to determine the present state of the system





Method

30-36 questions representing normal control room identification tasks

All questions require an answer

- but 'Don't Know' option available (omission)

Response time and **accuracy** are measured

- Time is taken from question appears to "move to next question" command is given
- Accuracy represents the converse to commission error

Recovery possible before "move to next question" command

- but not possible to go back to previous questions

Participants

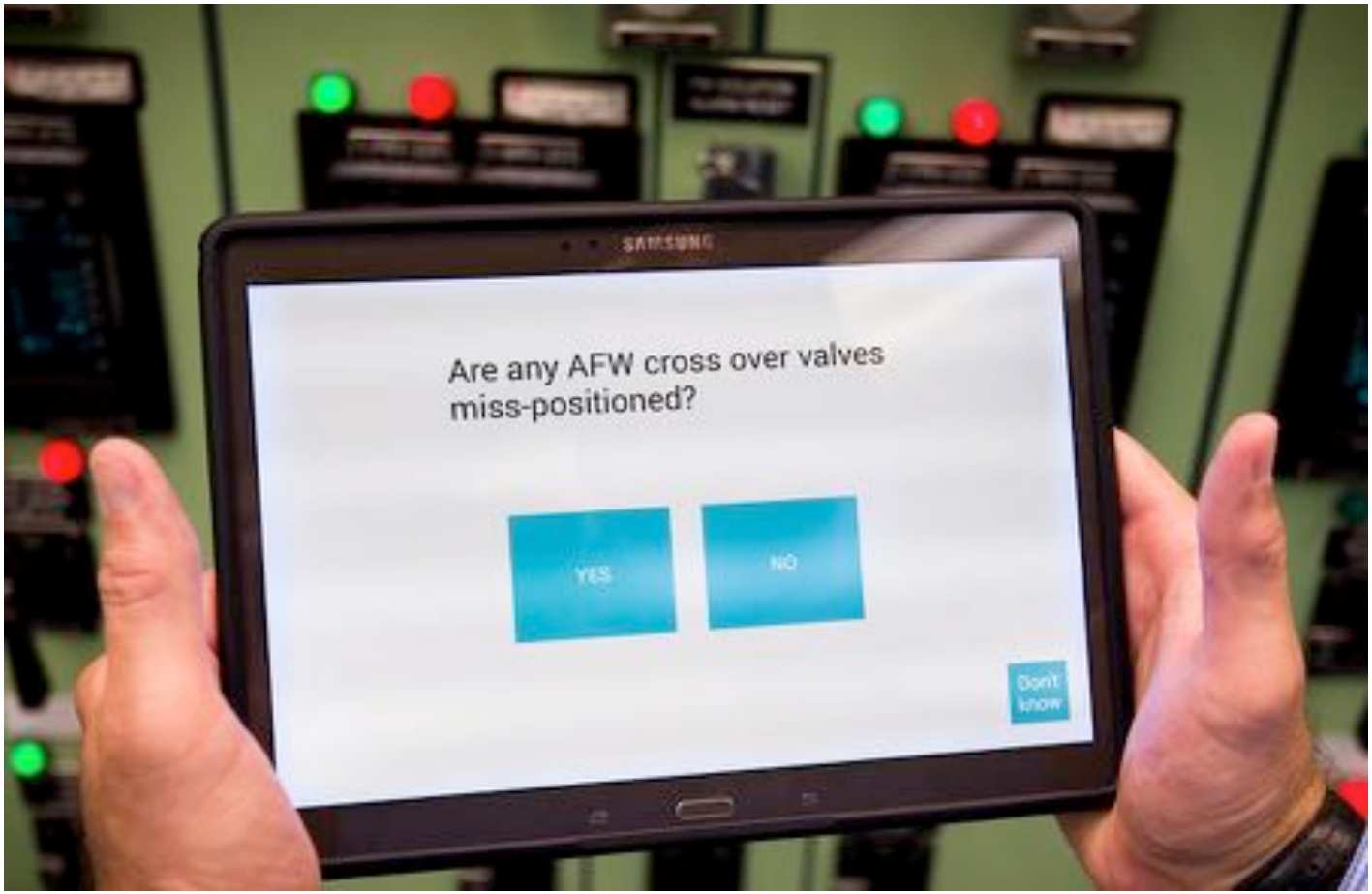
U.S. + Swedish Crews

16 + 9 operators

3-4 operators per exercise answered independently in different control room locations

Trivia questions before the test to familiarize with the app

Questions



Questions relate to indications available on the panels/display in front of the participant

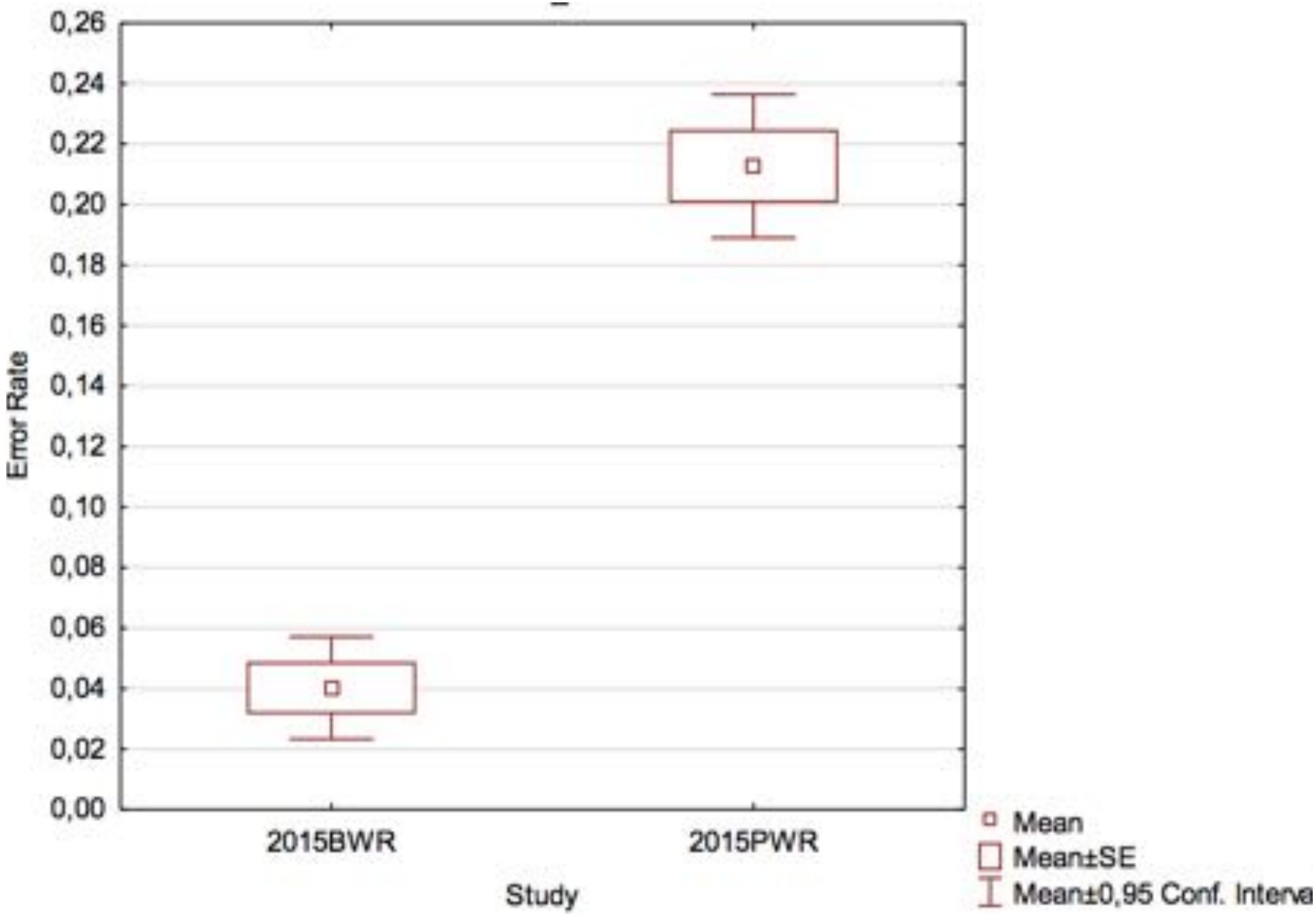
Part of real control room tasks

Easy-to-understand and quickly answerable individually (<20 s)

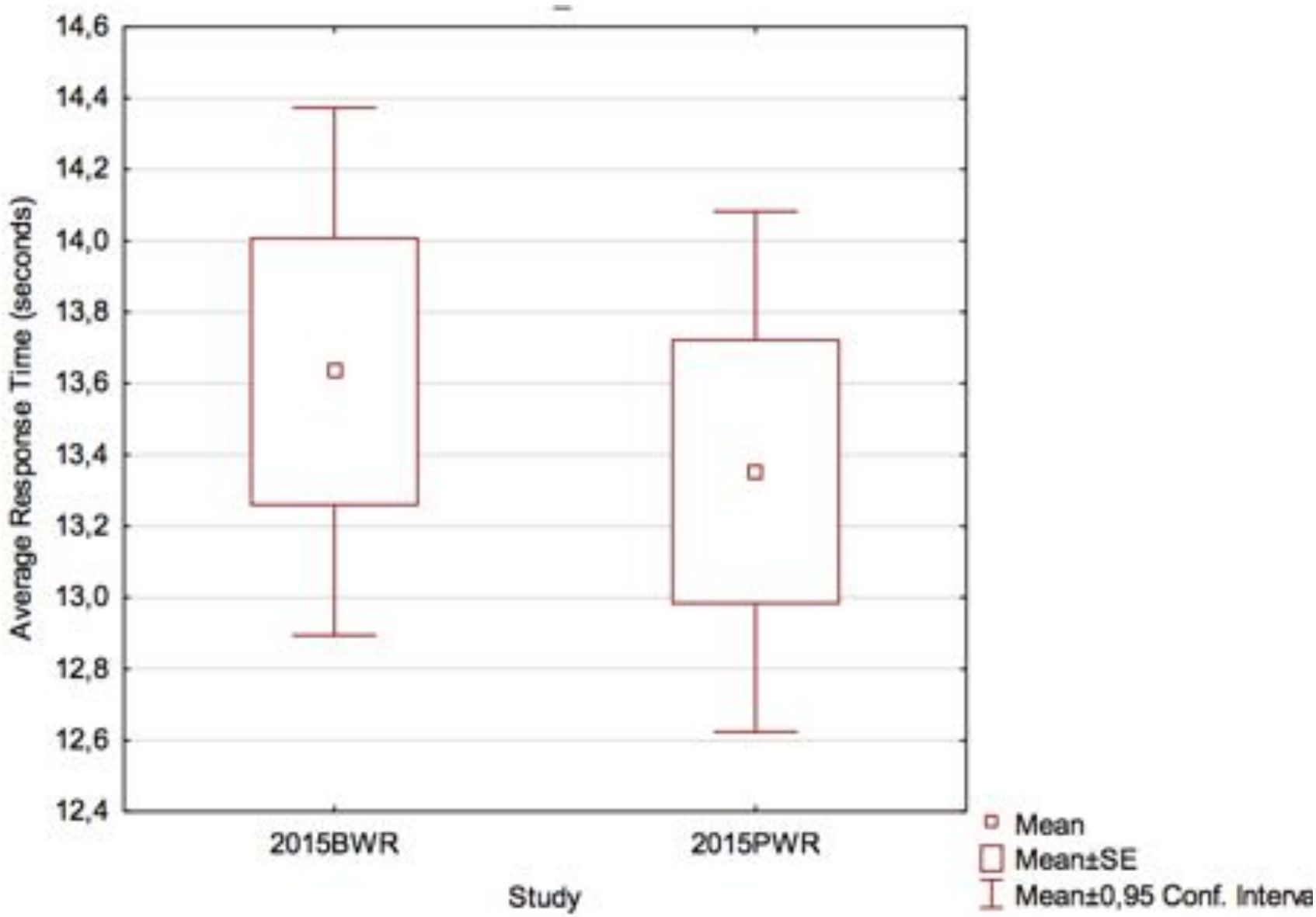
Single choice between options or numerical entry

Results

Error Rates by Study

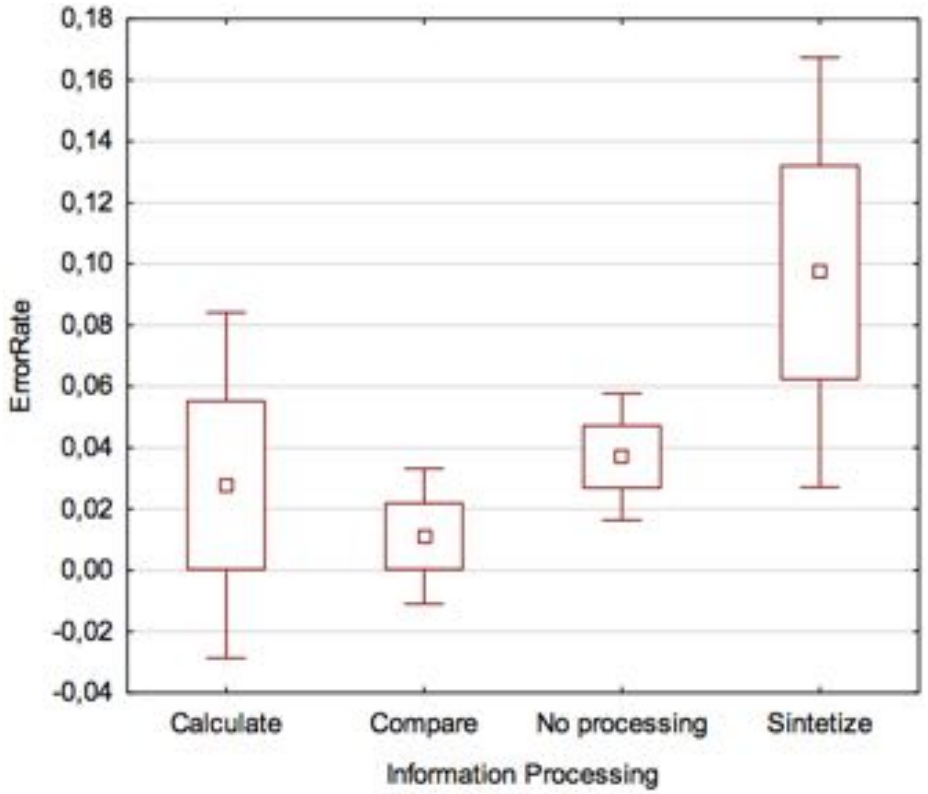


Response Time by Study

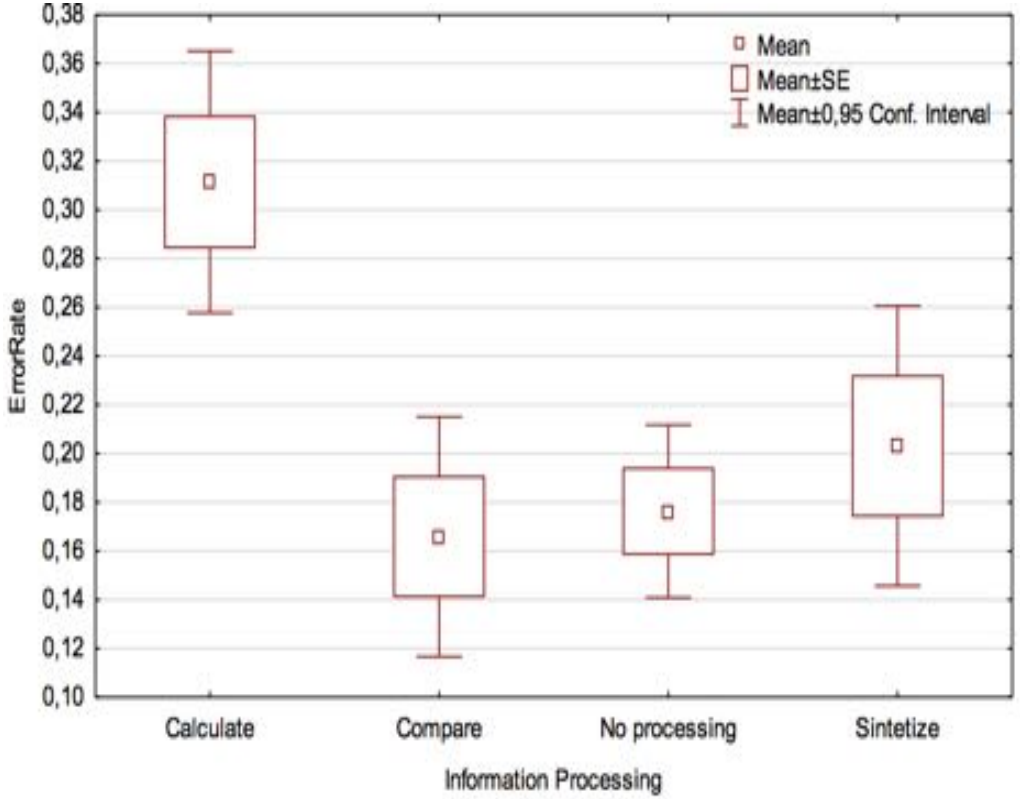


Error rates by Information Processing

BWR study

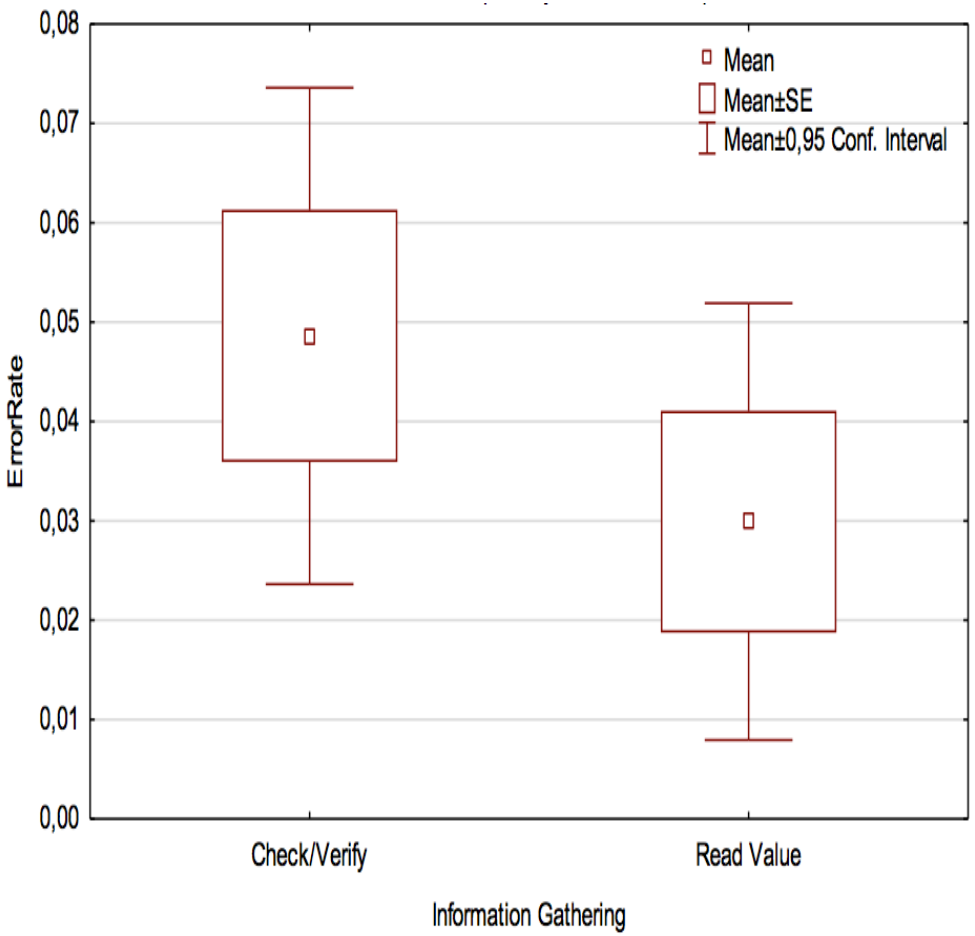


PWR study

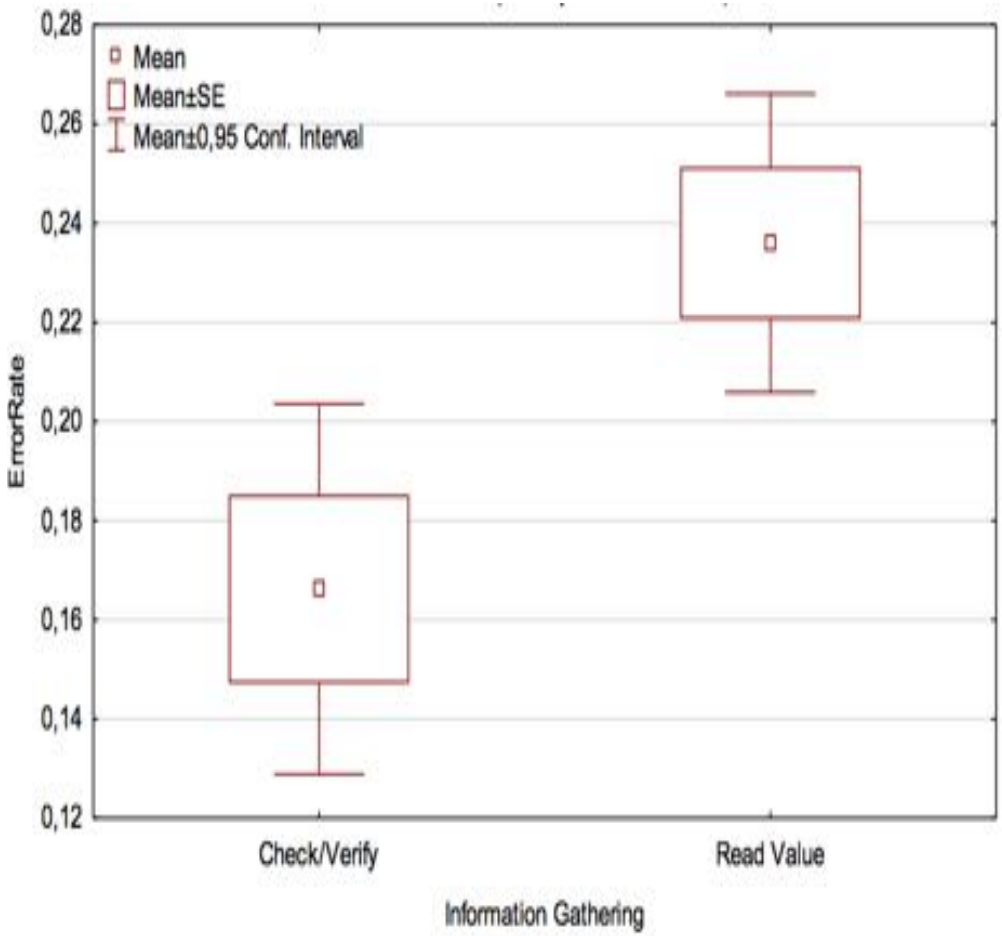


Error rates by Information Gathering

BWR study

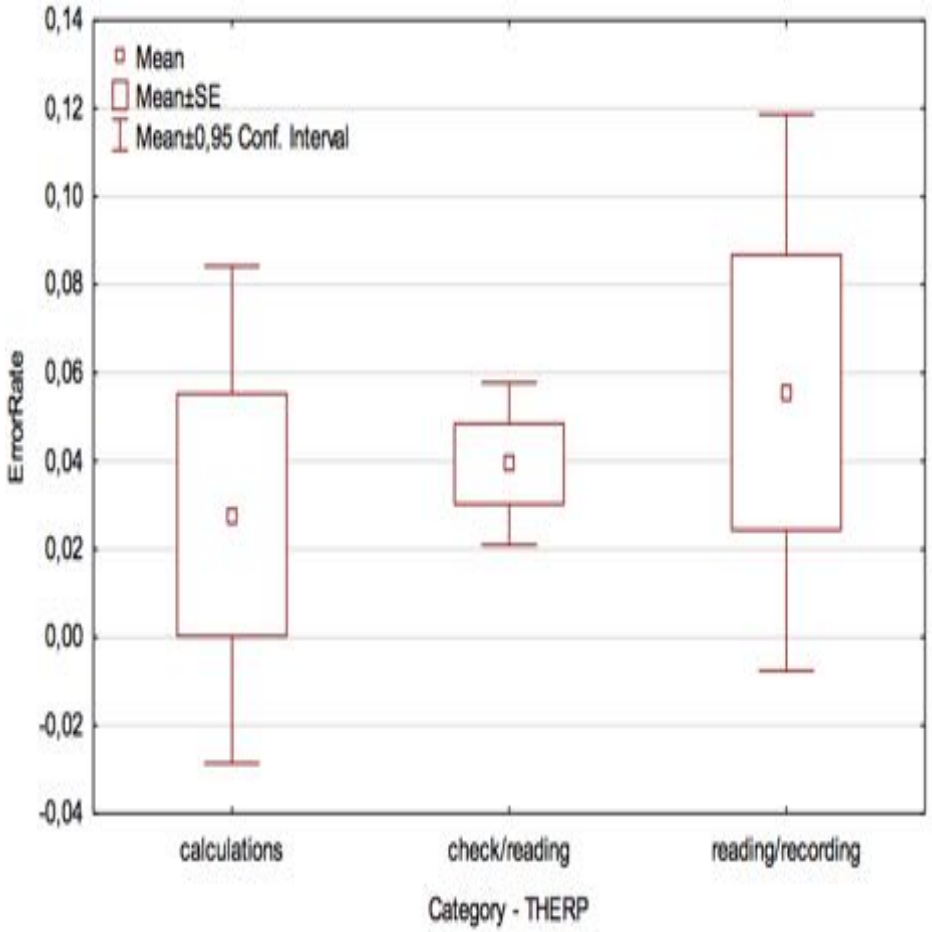


PWR study

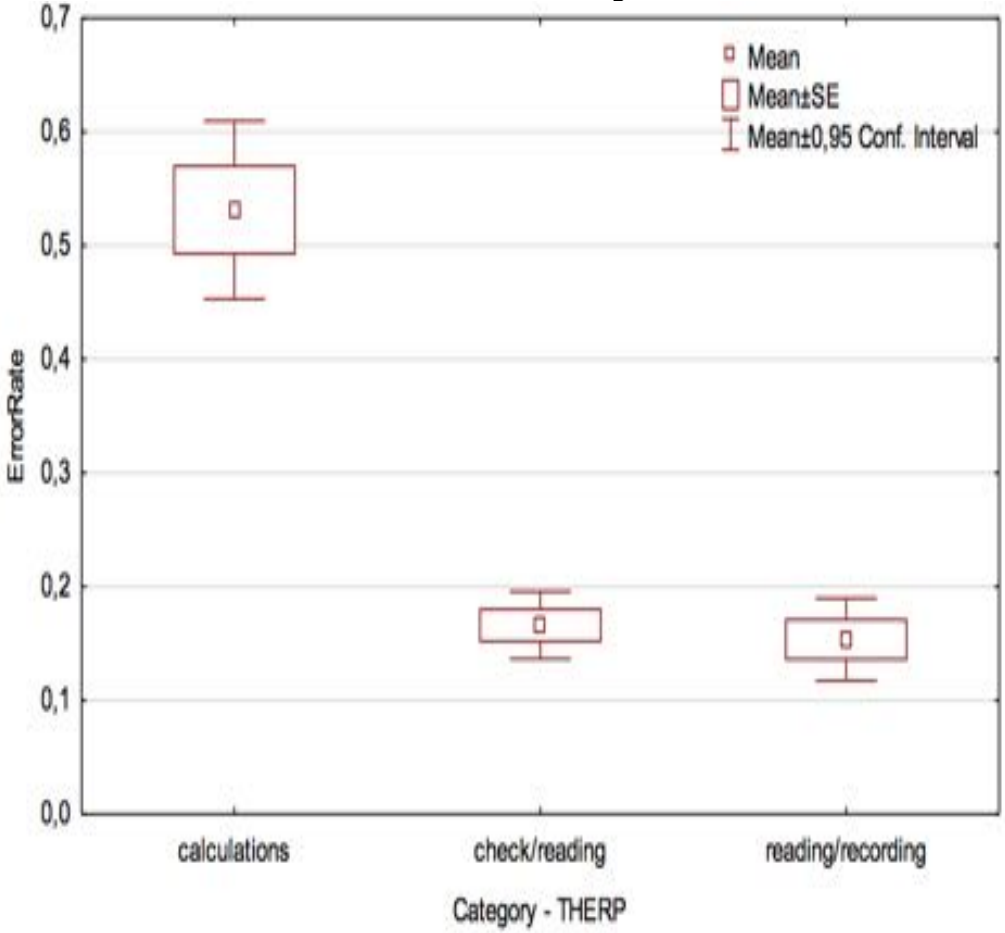


Error rates by THERP Categories

BWR study

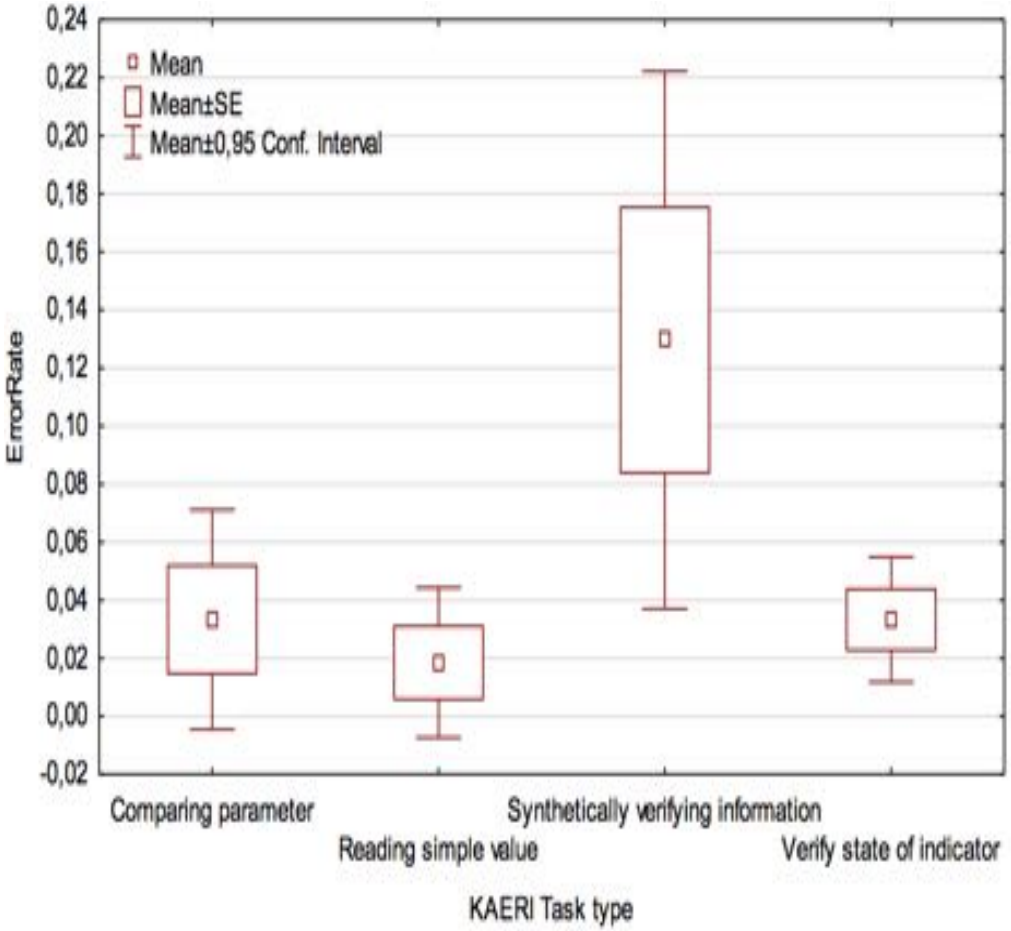


PWR study

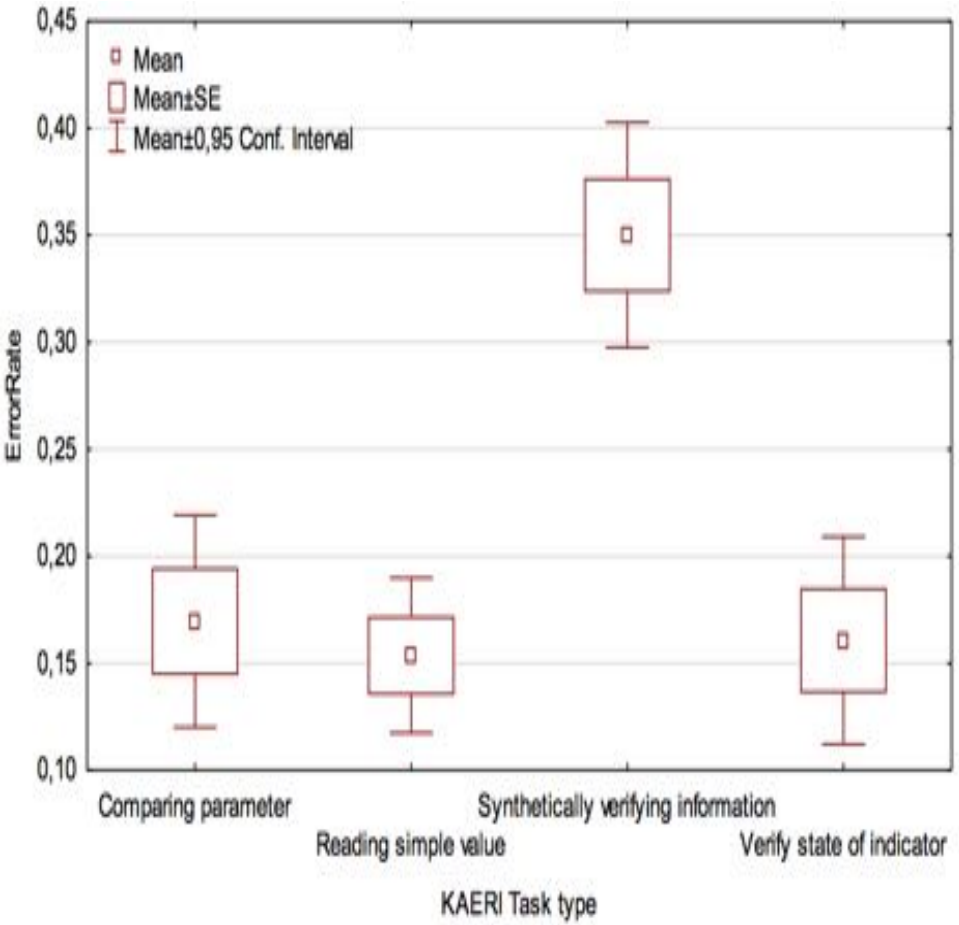


Error rates by KAERI Categories

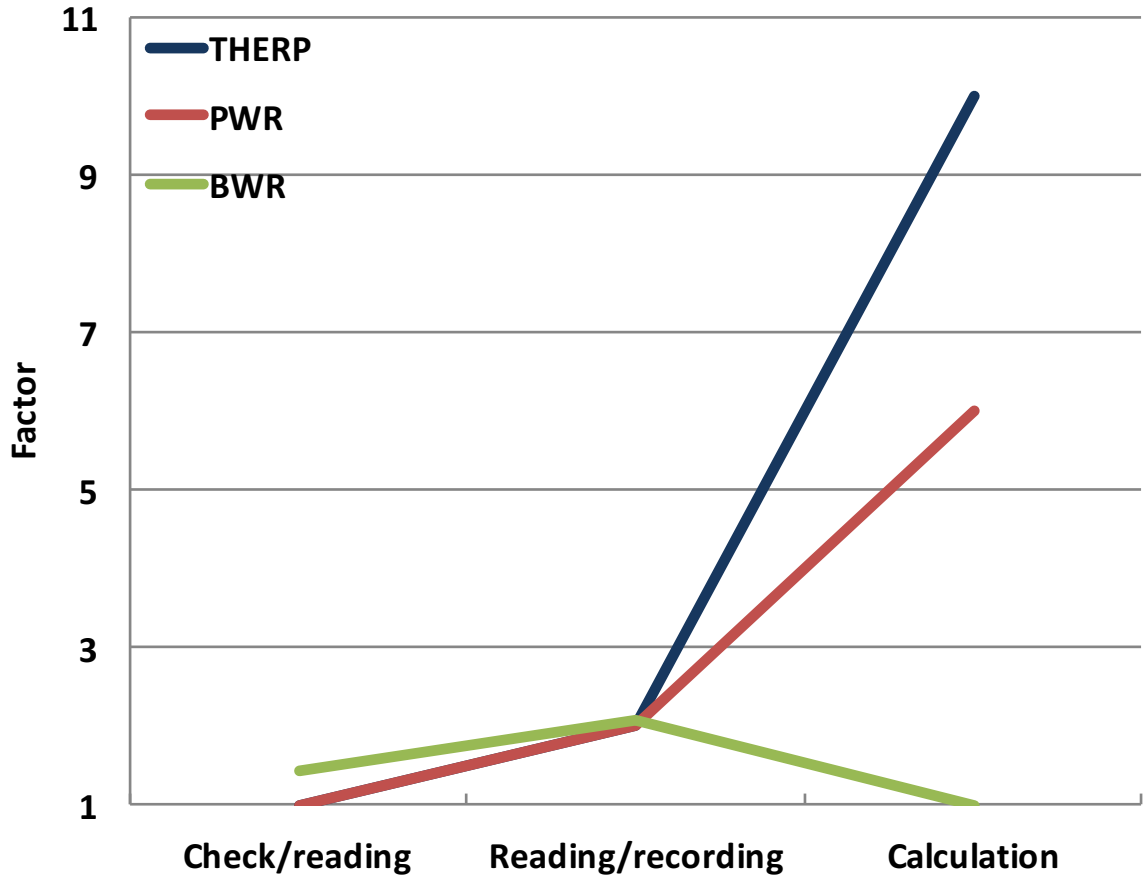
BWR study



PWR study

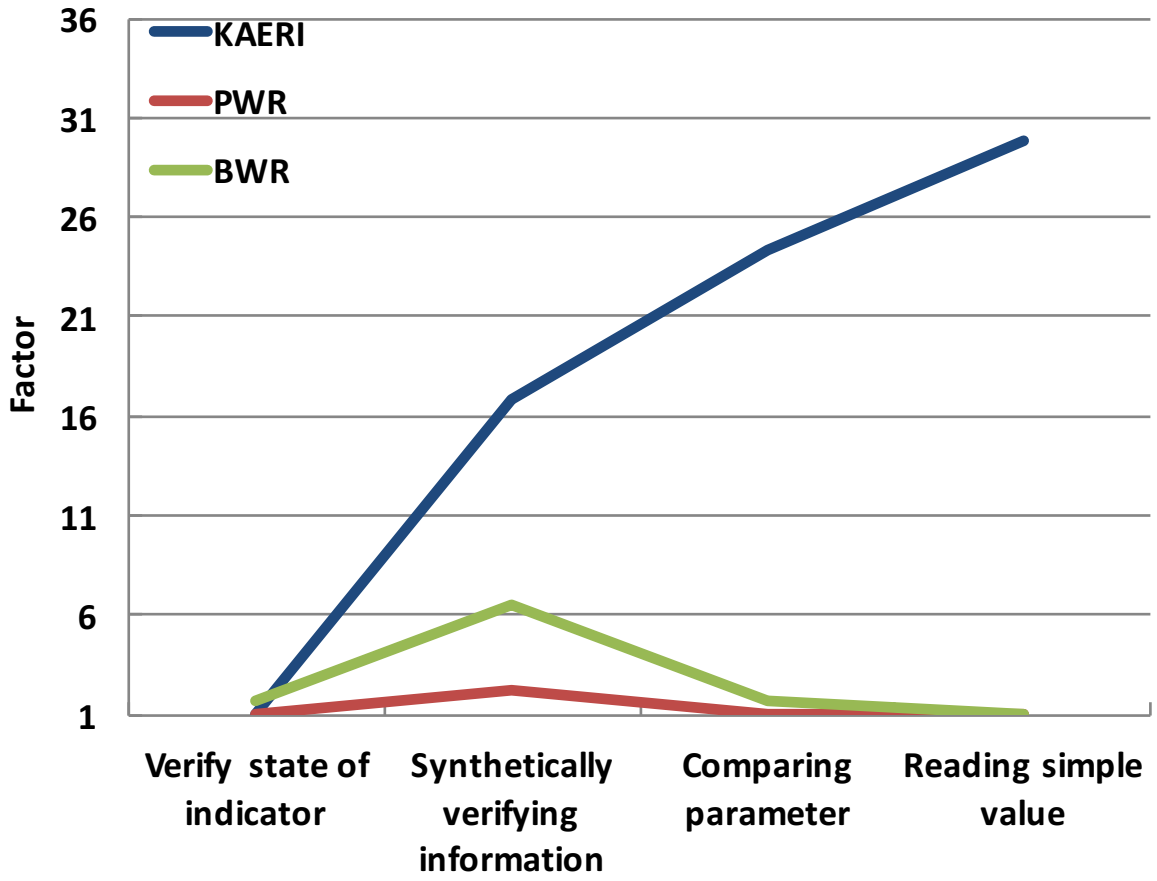


THERP HEPs relative rankings



Task	THERP	PWR	BWR
Check/reading	1	1	x1
Reading/recording	x2	x2	x2
Calculation	x10	x6	1

KAERI HEPs relative rankings



Task	KAERI	PWR	BWR
Verify state of indicator	1	x1	x2
Synthetically verifying information	x17	x2	x7
Comparing parameter	x24	x1	x2
Reading simple value	x30	1	1

Main findings

1. Large error rates differences between the two data sets

2. Ranking differences among cognitive task types not always consistent across data sets

3. Published HEPs rankings for identification task types not very consistent with Micro-Task data

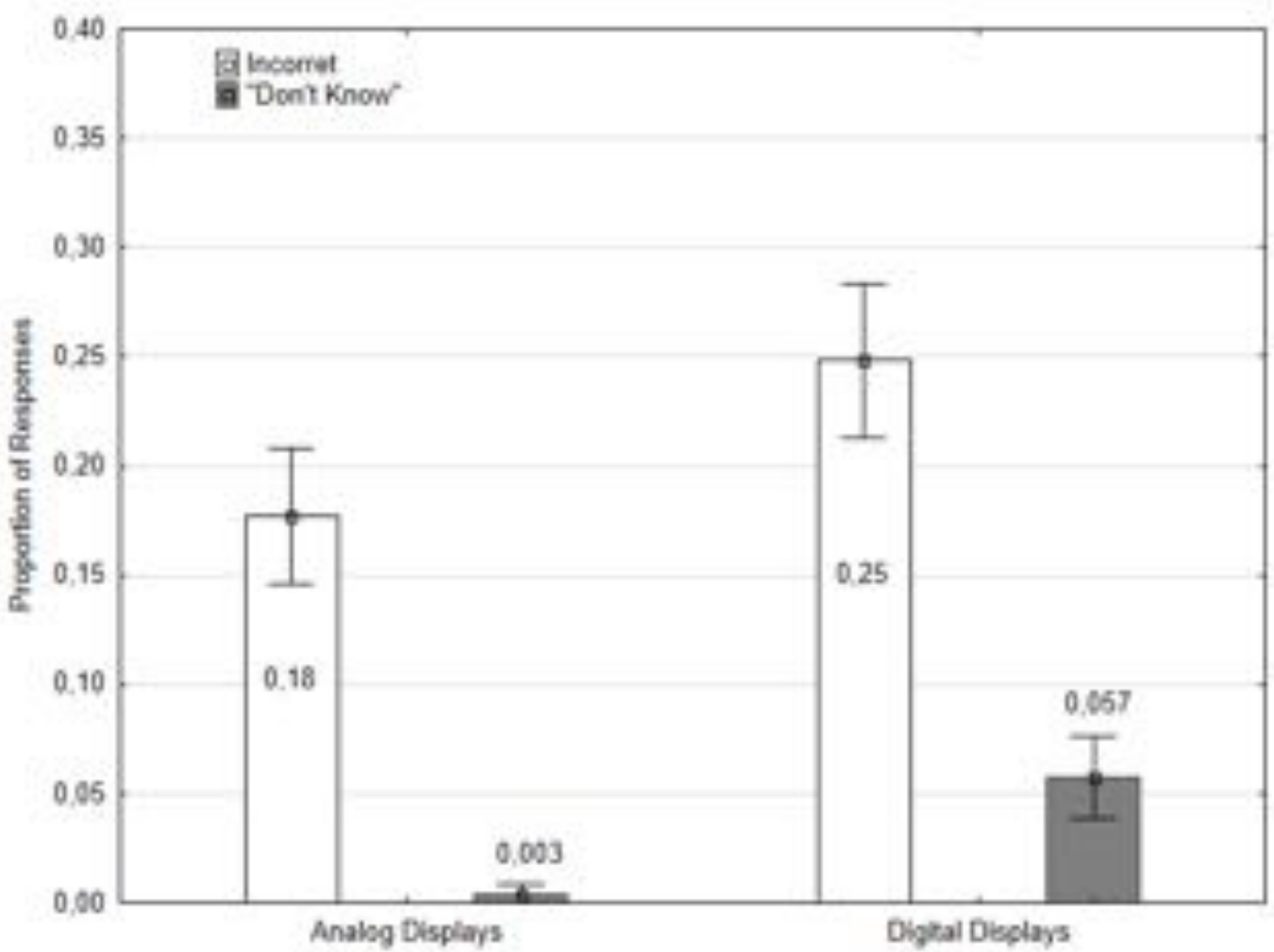
4. Need further research on the methodology

Extra slides

PWR only, Analog vs. Digital

Overall failure rates

Incorrect = wrong + 'Don't Know'



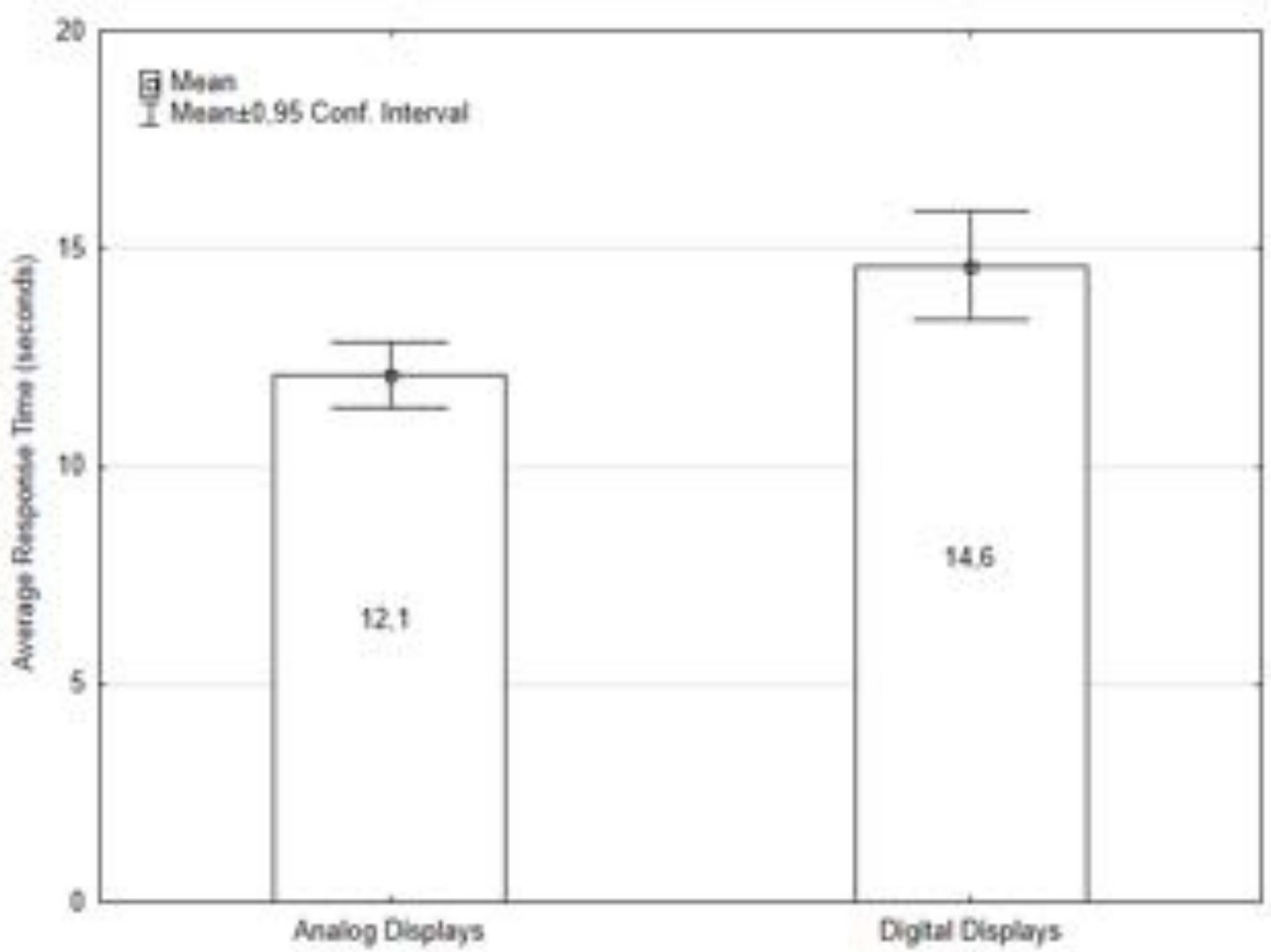
Slightly less errors with the analog panels

17% more commission errors with the digital HSI but difference is not statistically significant

Significantly more omissions with digital displays ("don't know" answers)

High error rates

Response time



The participants were faster with the analog panels

$t(1115) = 3.00$, $p < .005$

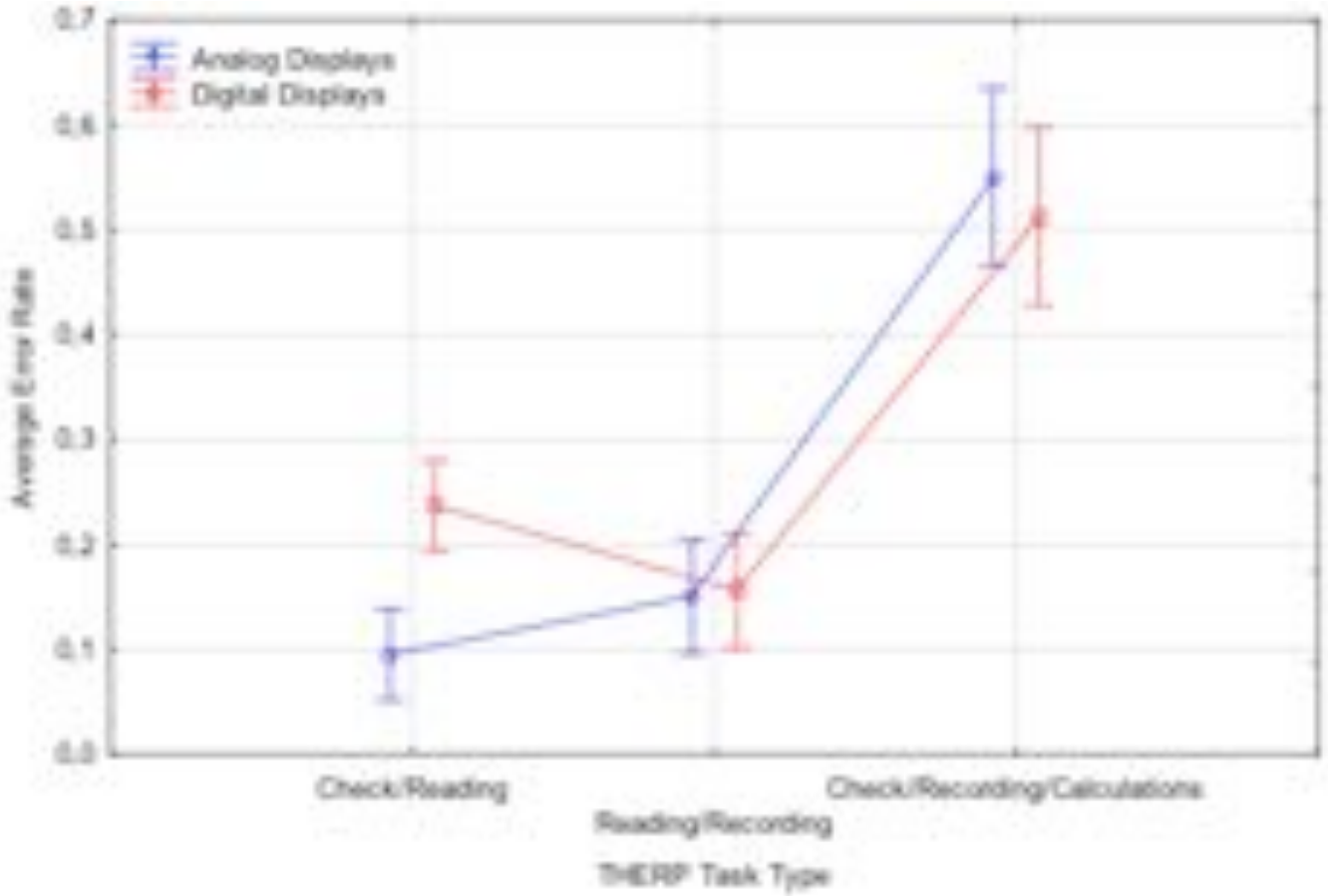
No speed-accuracy trade-off: faster participants had lower error rates

$t(1115) = -9.37$, $p < .001$

In the following analyses we consider commission errors only

"Don't Know" answers are removed

THERP Task Types



Error rates differences among THERP tasks

$F(2, 1111) = 62.72$, $p < .001$, $\eta^2 = .10$

Similar error rates for the two HSIs

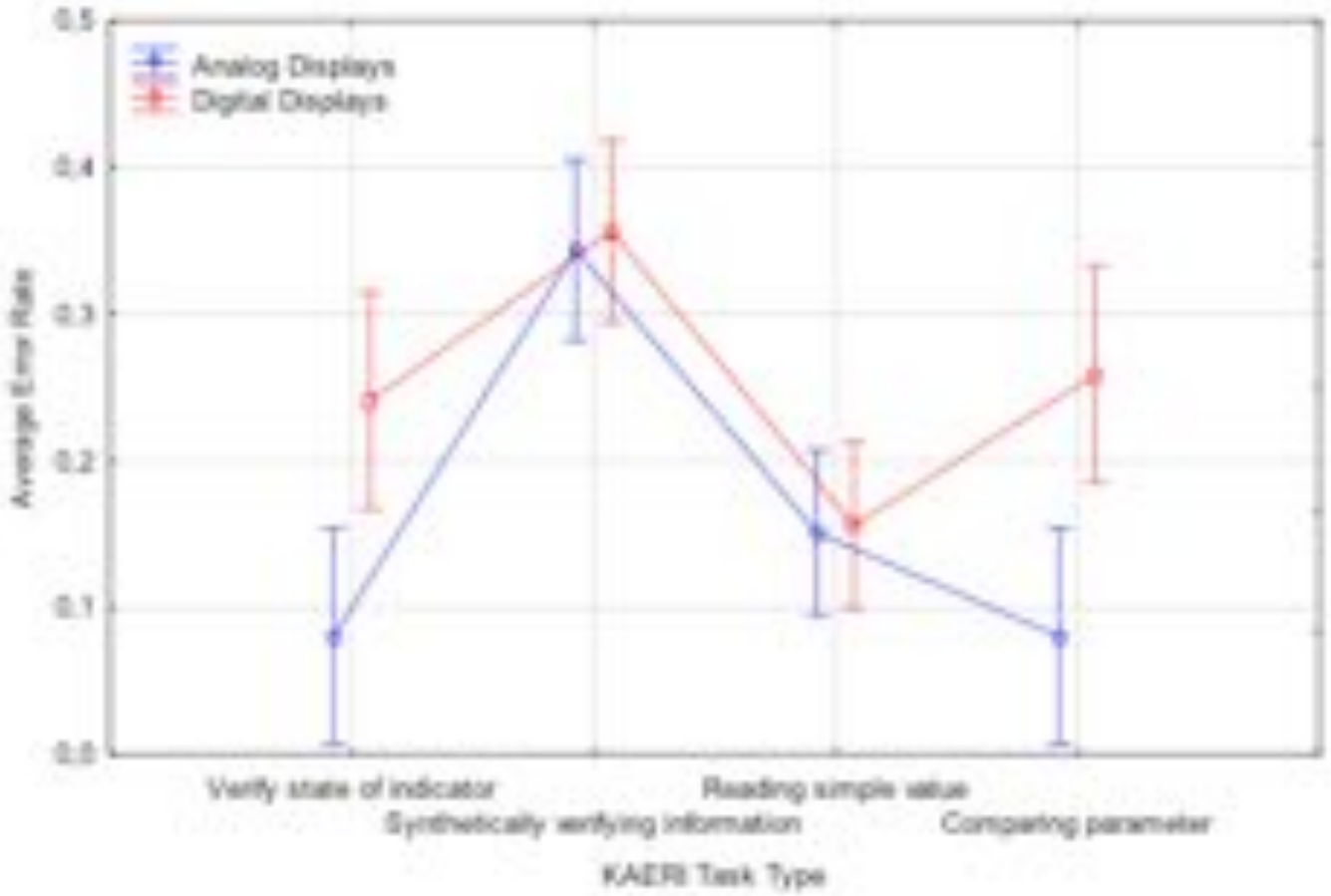
$F(1, 1111) = 0.002$, $p = .96$

Errors rates between HSIs differ by task types (interaction)

$F(2, 1111) = 3.53$, $p = .003$, $\eta^2 = .006$

On analog panels ‘Check/recording/calculations’ 6x more errors than the other task types

KAERI Task Types



Different error rates for the task types

$F(3, 1109) = 18.10$, $p < .001$, $\eta^2 = .04$

No main effect of the HSI

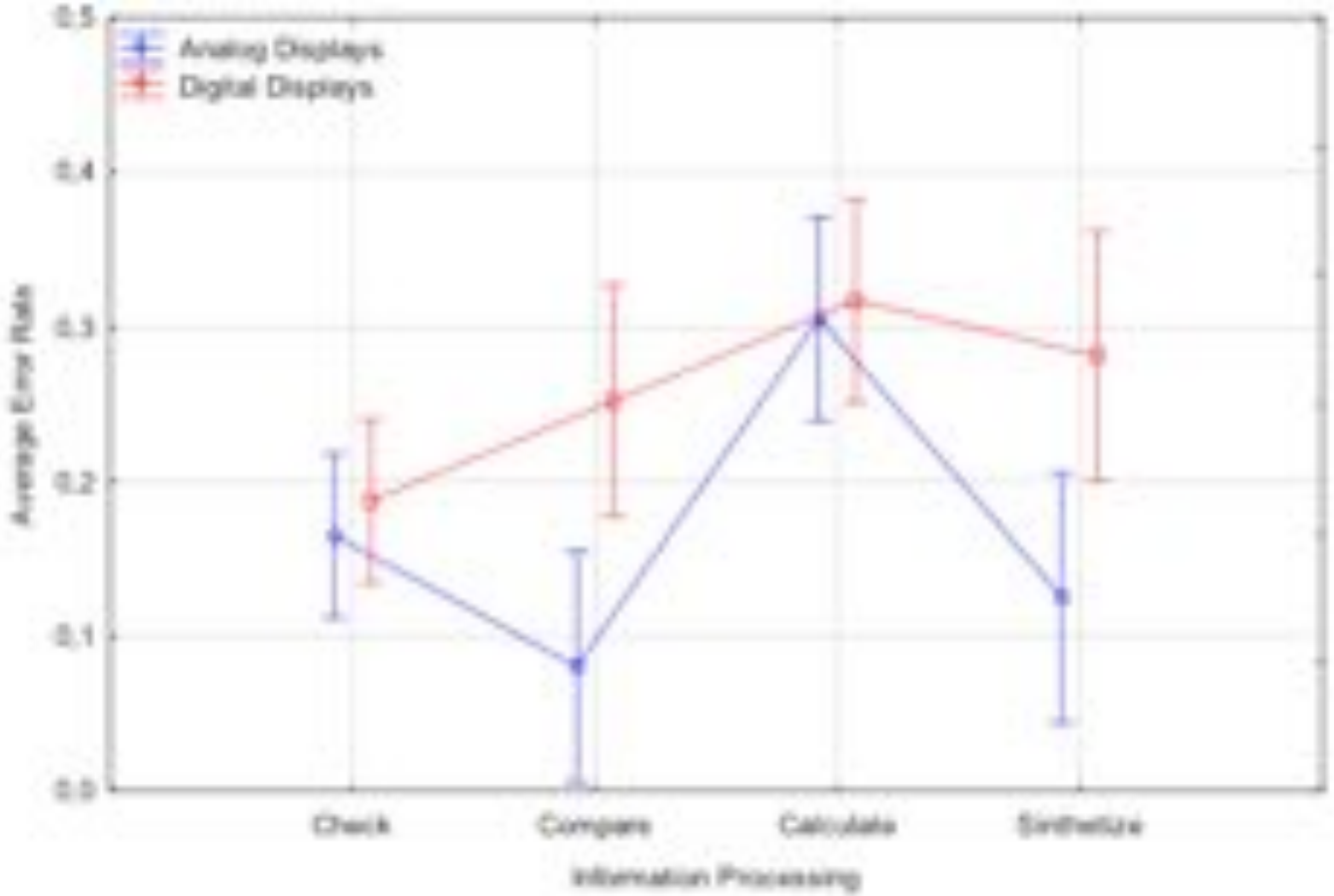
$F(1, 1109) = 3.04$, $p = .08$

No interaction between HSI and task type

$F(3, 1109) = 2.15$, $p = .09$

In the analogue panels task type error rate differences up to factor 4

Information Processing Types



Different error rates for different processing types

$F(3, 1109) = 7.65$, $p < .001$, $\eta^2 = .02$

No main effect of the HSI

$F(1, 1109) = 3.08$, $p = .07$

In the analog panels error rates differences up to 3x