PARENT

A.I.LAB Ljubljana

AI/ML in healthcare

Aleksander Sadikov

Artificial Intelligence Laboratory
University of Ljubljana
Faculty of Computer and Information Science

The PARENT project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie – Innovative Training Network 2020, Grant Agreement N° 956394

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ABML in healthcare

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Learning to diagnose pneumonia

Patient no.	Temperature	Coughing	Gender	Pneumonia
1	Normal	No	Female	No
2	High	Yes	Male	Yes
3	Very high	No	Male	Yes

A typical rule learner would induce the rule:

IF Gender = Male THEN Pneumonia = Yes

This will correctly diagnose all patients

But it will explain Patient 3 by: Has pneumonia because he is male

How to Fix this with Argument Based Machine Learning?

Patient no.	Temperature	Coughing	Gender	Pneumonia
1	Normal	No	Female	No
2	High	Yes	Male	Yes
3	Very high	No	Male	Yes

A possible expert's explanation for Patient 2:

Patient 2 suffers from pneumonia because he has high temperature

In ABML we say: Expert **annotated** this case by **positive argument**

The previous rule is now not consistent with the **argument**

ABML TAKES EXPERT'S ARGUMENT INTO ACCOUNT

Patient no.	Temperature	Coughing	Gender	Pneumonia
1	Normal	No	Female	No
2	High	Yes	Male	Yes
3	Very high	No	Male	Yes

ABML induces the rule consistent with expert's argument:

IF Temperature > Normal THEN Pneumonia = Yes

This explains Patient 3 by:

Has pneumonia because he has very high temperature

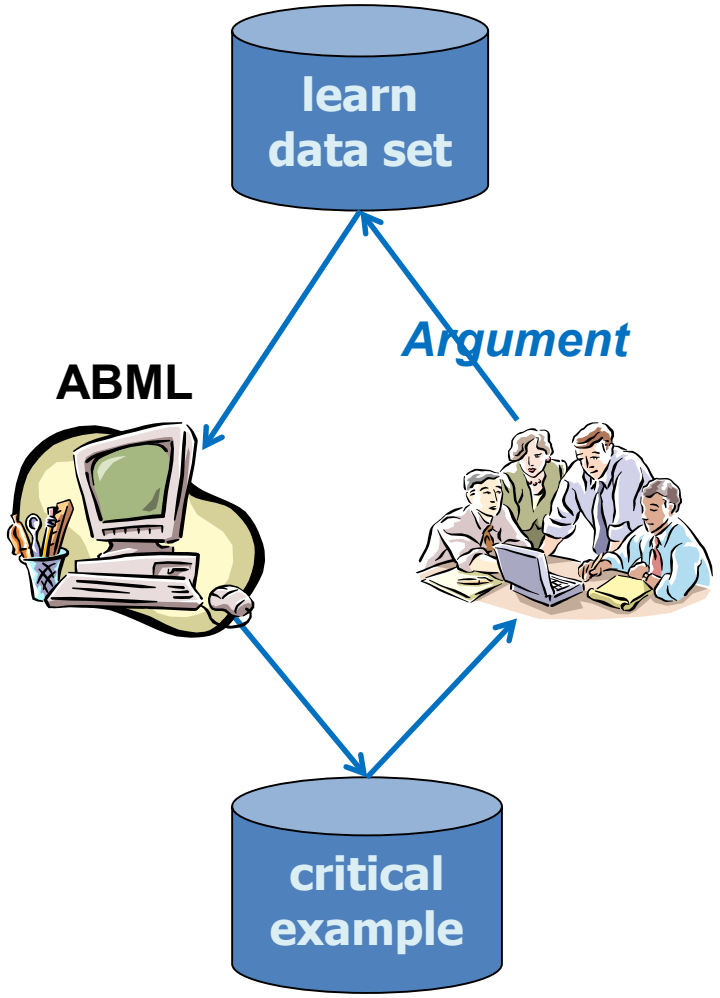
ABML Knowledge Refinement Loop

Step 1: Learn a hypothesis with ABML

Step 2: Find the "most critical" example
(if none found, stop)

Step 3: Expert explains the example

Return to step 1



ABML Knowledge Refinement Loop

Step 1: Learn a hypothesis with ABML

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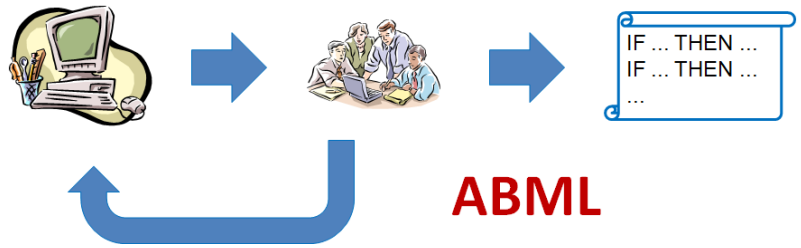
Step 3: **Expert explains the example**



Return to step 1

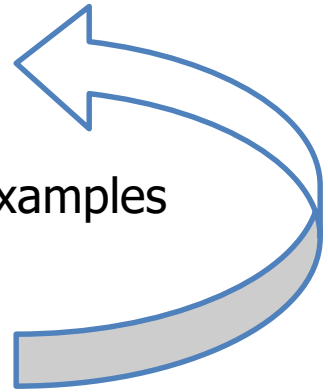
Step 3a: Explaining a critical example (in a natural language)

Step 3b: Adding arguments to the example

Step 3c: Discovering **counter examples**

Step 3d: Improving arguments with counter examples

Return to step 3c if counter example found



ABML Refinement Loop & Knowledge Elicitation

critical examples
counter examples

IF ... THEN ...
IF ... THEN ...
...

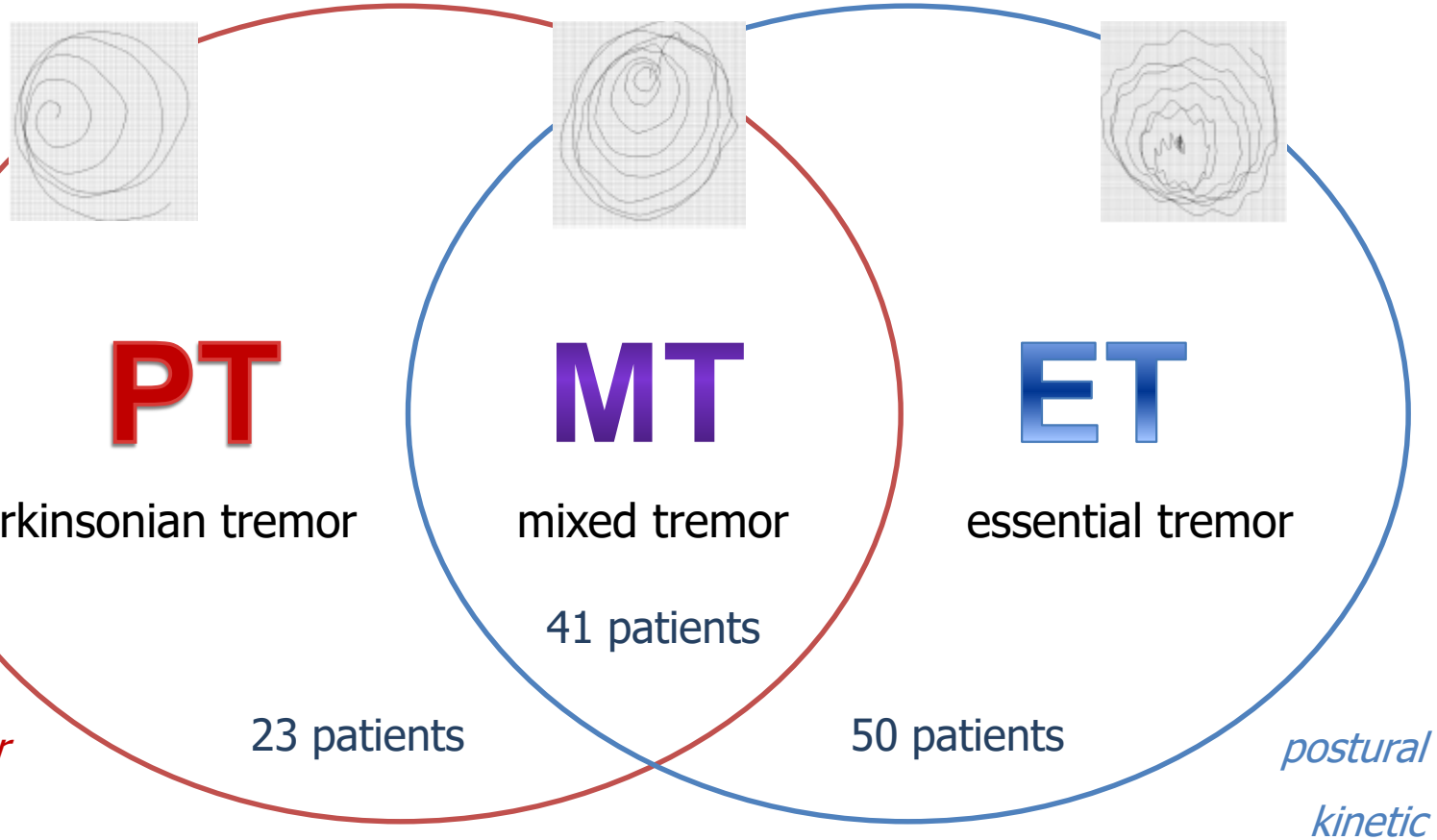
arguments

ABML

argument-based machine learning

explain single example	→	easier for experts to articulate knowledge
“critical” examples	→	expert provides only relevant knowledge
“counter” examples	→	detect deficiencies in explanations

Differentiating Tremors: Domain Description



resting tremor

bradykinesia

rigidity

Parkinsonian spiral drawings

...

postural tremor

kinetic tremor

harmonics

essential spiral drawings

...

Data set of 114 patients:

- learning set: 47 examples
- test set: 67 examples

The patients were described by **45 attributes**.

The Final Model

#	Condition	Class	+	−	E
1	IF Qualitative.Assessment = *ET*	EMT	21	0	1
2	IF Bradykinesia = *false*	EMT	18	0	1
3	IF Bradykinesia = *true* AND Rigidity = *true*	PMT	17	0	2
4	IF Qualitative.Assessment = *ET* AND Postural = *true*	EMT	16	0	1
5	IF Rigidity = *false* AND Kinetic = *true*	EMT	15	0	1
6	IF Kinetic = *true* AND Bradykinesia = *false*	EMT	13	0	1
7	IF Spiro.Free.PT.only = *true* AND Spiro.Template.ET.only = *false*	PMT	13	0	1
8	IF Harmonics = *true*	EMT	12	0	2
9	IF Resting = *true* AND Harmonics = *false* AND Rigidity = *true*	PMT	12	0	2
10	IF Postural = *true* AND Kinetic = *true* AND Resting = *false*	EMT	10	0	1
11	IF Qualitative.Assessment = *PT*	PMT	10	0	1
12	IF Resting = *false* AND Postural = *true* AND Bradykinesia = *false*	EMT	8	0	2
13	IF Postural = *true* AND Anamnesis = *positive* AND Bradykinesia = *false*	EMT	8	0	2
14	IF Spiro.Free.ET.only = *true* AND Spiro.Template.ET.only = *true*	EMT	7	0	1

no counter-intuitive rules

pure distributions

classification accuracies on the test set:

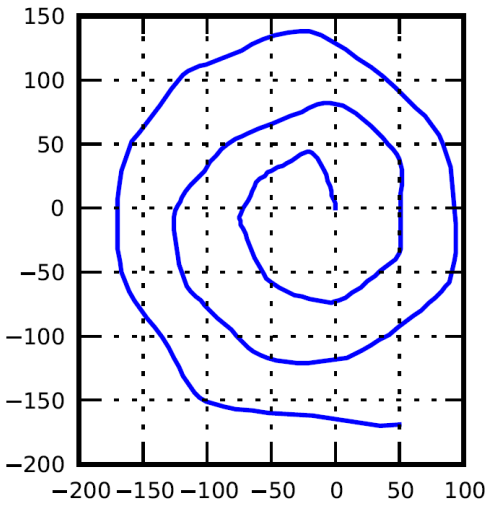
Method	**Initial model**	**Final Model**
Naive Bayes	63%	74%
kNN	58%	81%
Rule learning (ABCN2)	52%	**82%**

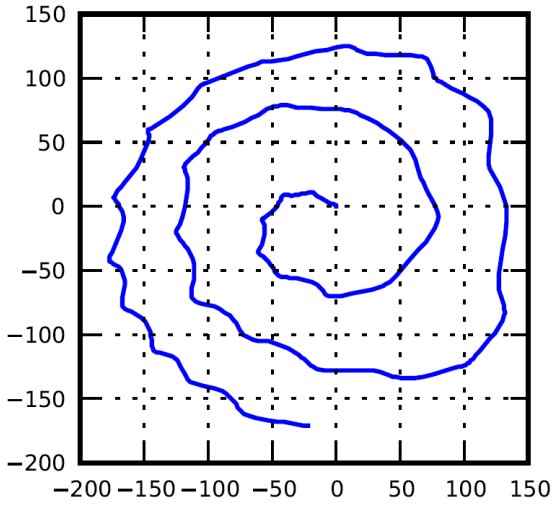
The accuracies of all methods improved **by adding new attributes**.

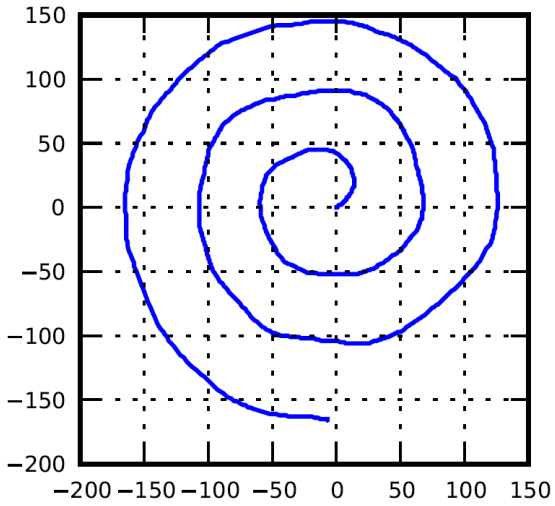
ParkinsonCheck™

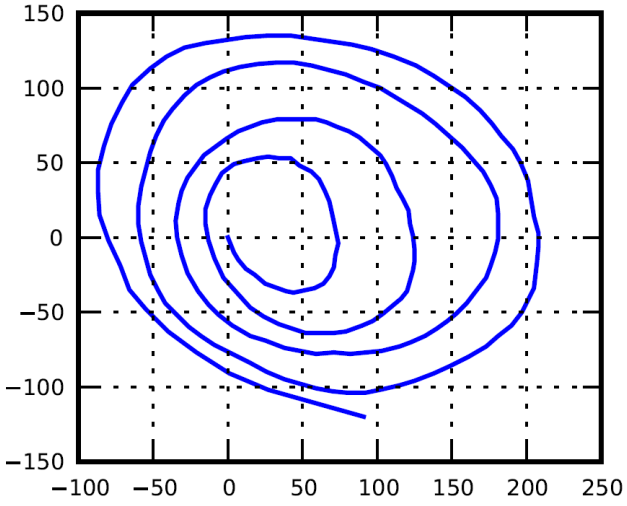
ParkinsonCheck™

- Smartphone app for early detection of signs of Parkinson's disease or essential tremor
- Freely available
- Built-in expert system, the user can do the test in home environment
- The app is completely stand-alone, no need for any communication with the server
- Uses spirography (touch sensor)









Which one was drawn by a healthy person?

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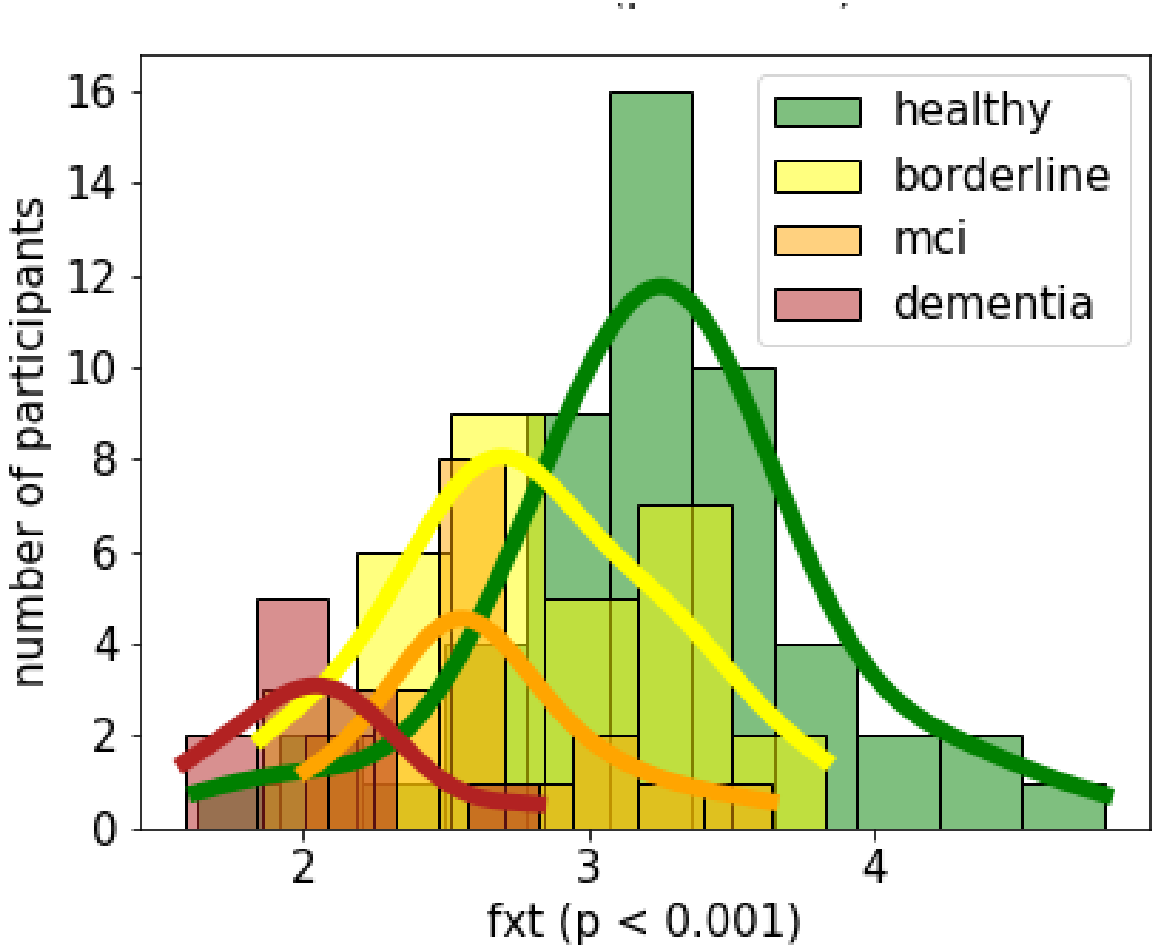
EIT Health (2019) project in collaboration with startup Neus Diagnostics, d.o.o.

- Early detection of mild cognitive impairment (MCI) that often precedes dementia.
- Based on eye-tracking during the execution of various digitised neuropsychological tasks.
- An example task: reading.

neus™
eye-tracking neurodiagnostics

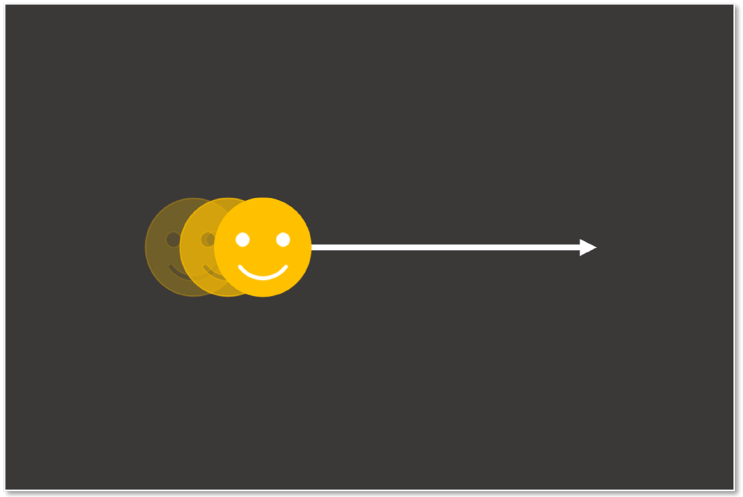


PARENT Project

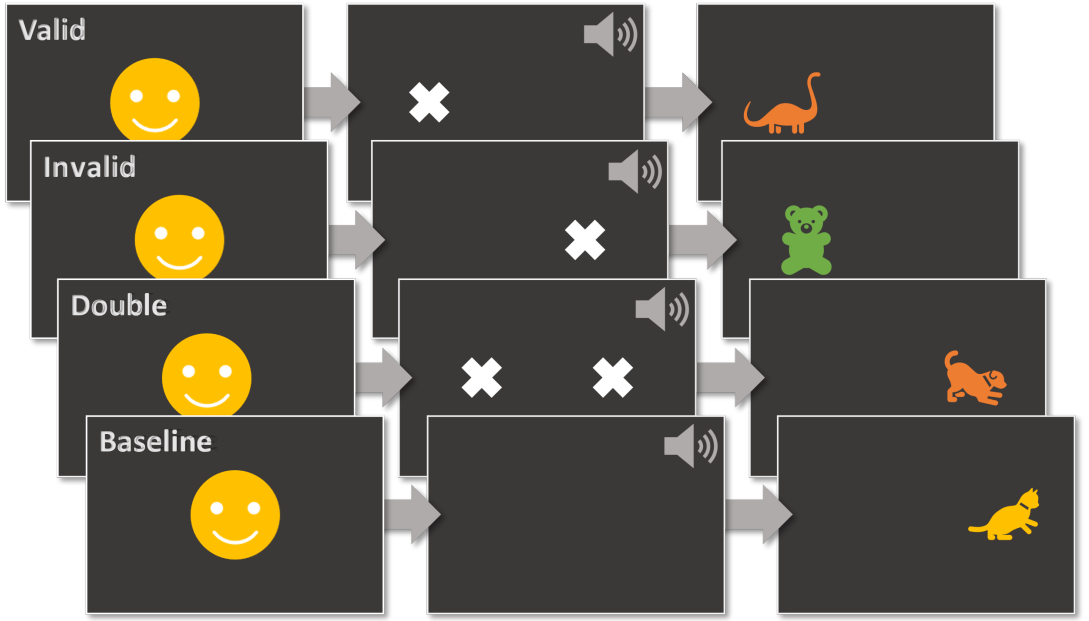
UNIVERSITY OF LJUBLJANA
marta.malavolta@fri.uni-lj.si

- PARENT project aims at **early detection** of **motor and cognitive problems** due to premature birth, which is one of the main causes of neonatal impairments and mortality.
- Our group is focused on the development of a neuropsychological test battery using **eye-tracking** for an early diagnosis of cognitive impairments.

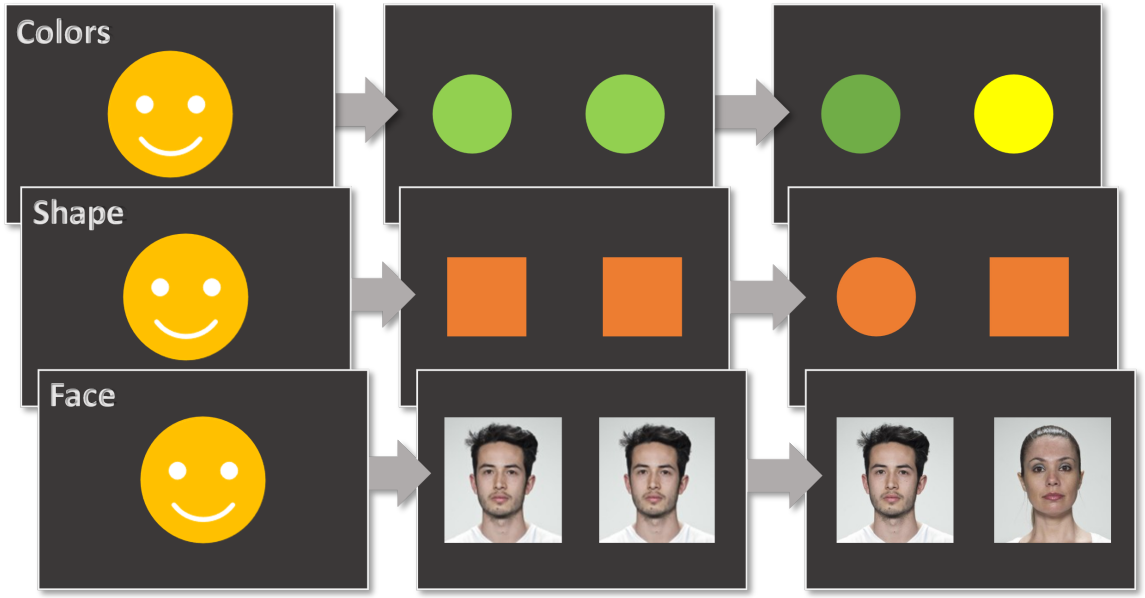
A. Smooth Pursuit Task



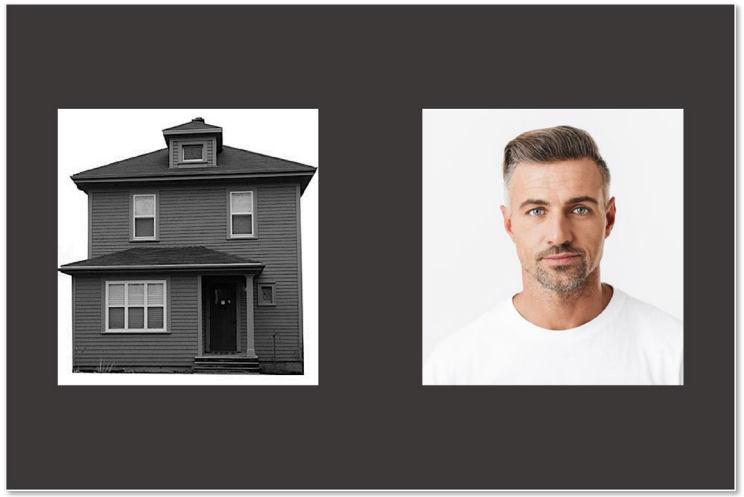
B. Attentional Task



C. Memory Task



D. Social Orienting Task



vida.groznik@fri.uni-lj.si
aleksander.sadikov@fri.uni-lj.si

www.parkinsoncheck.net
parenth2020.com

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KNOWLEDGE ELICITATION WITH ABML

critical examples
counter examples

IF ... THEN ...
IF ... THEN ...
...

arguments

ABML

argument-based machine learning

experts' arguments
constrain learning

obtained models are consistent
with expert knowledge

experts introduce
new concepts (attributes)

human-understandable models

Možina M. *et* al. Fighting Knowledge Acquisition Bottleneck with Argument Based Machine Learning. ECAI 2008.