Ethologically inspired robot design

How to develop social behaviour for non-humanoid robots based on dog behaviour?

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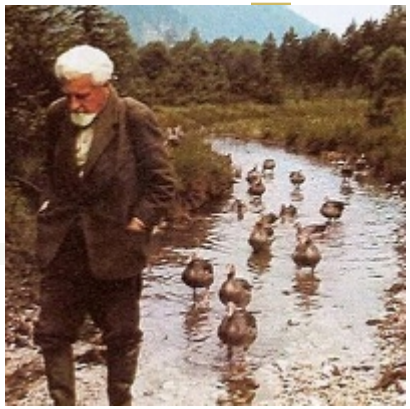
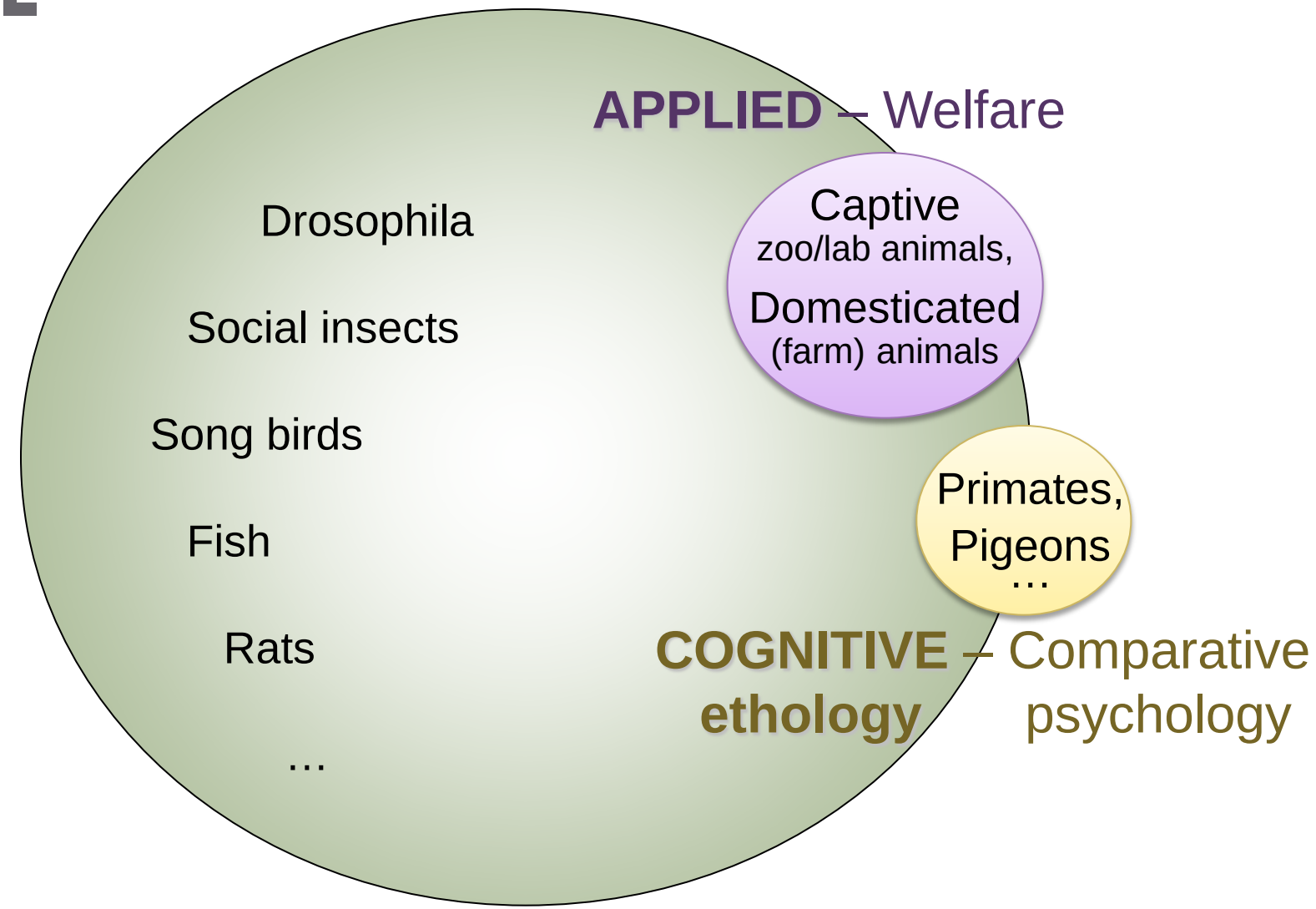
Ethological approach



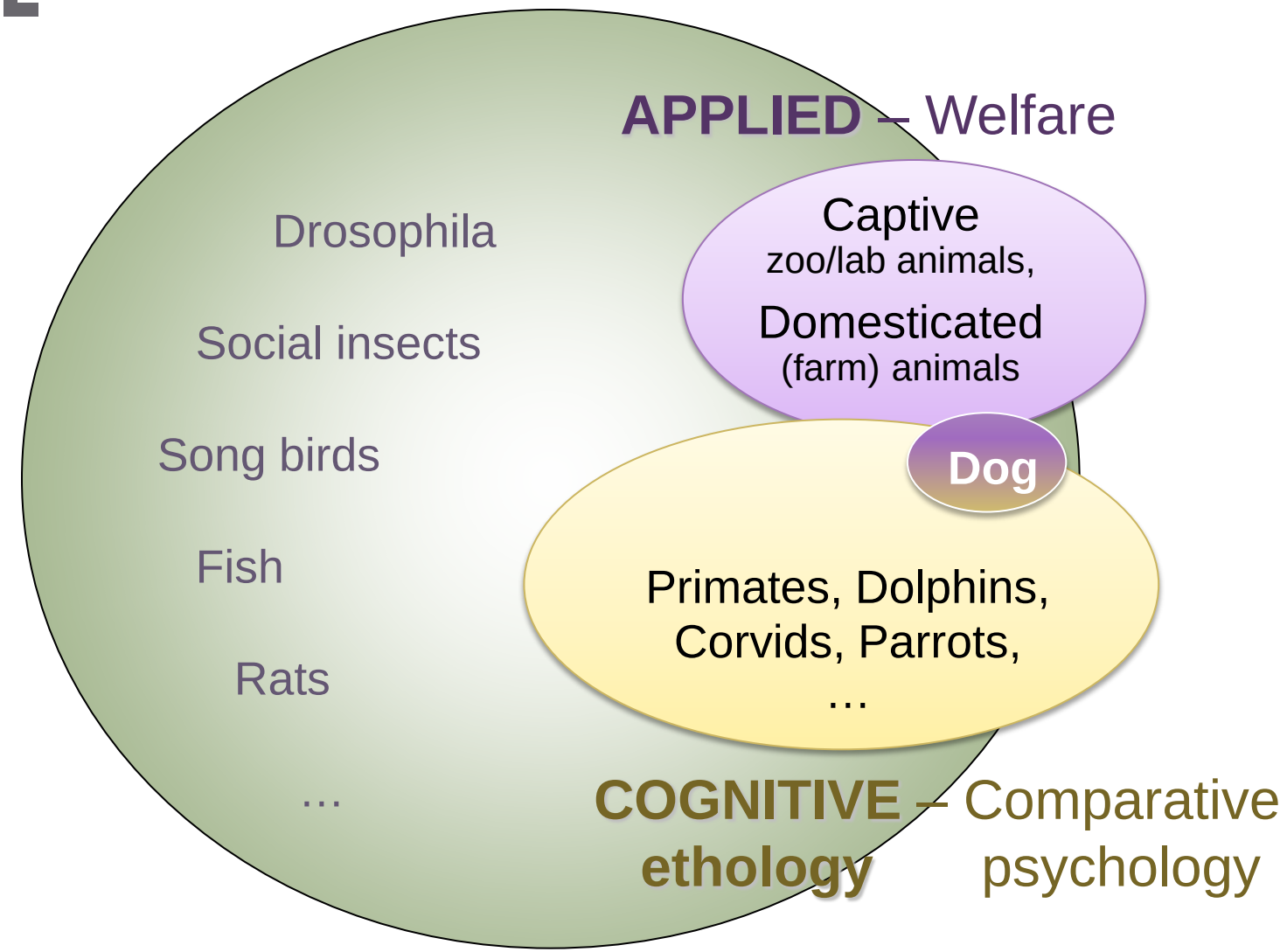
- **Ethology** → natural science, brench of biology
  study measurable behaviours from an evolutionary approach
  - observation + analyses + evaluation
    (behaviour elements → numbers → statistics)
  - natural behaviour of animals (including humans!)

- **Cognitive** ethology → study of mental processes in animals
  to reveal intentionality, awareness, and conscious thinking
  → non-observable → through behaviours during:
  - communication
  - cooperation
  - social learning…

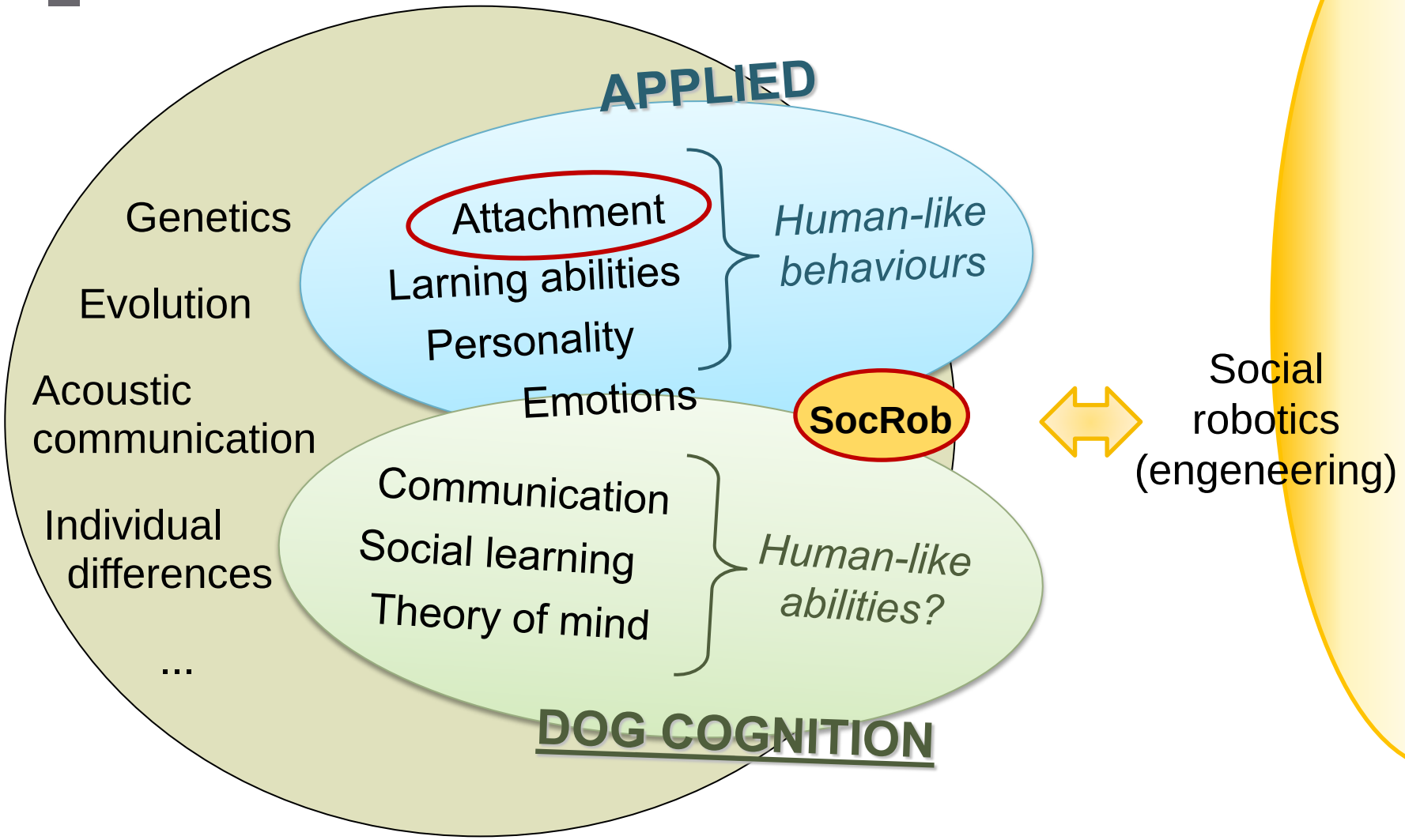
Ethology (15-20 years ago…)



Ethology (today)



Hot topics in DOG research



Attachment → behavioural system

Asymmetrical social relationship → presumes the dependency of the attached individual

attachment figure
→ secure base

Infant – mother relationship

How to measure?

Strange Situation Test (Ainsworth 1969) adapted to the dog (Topál et al. 1998)

⇩

Dog–owner attachment is analogous to human infant–parent attachment!

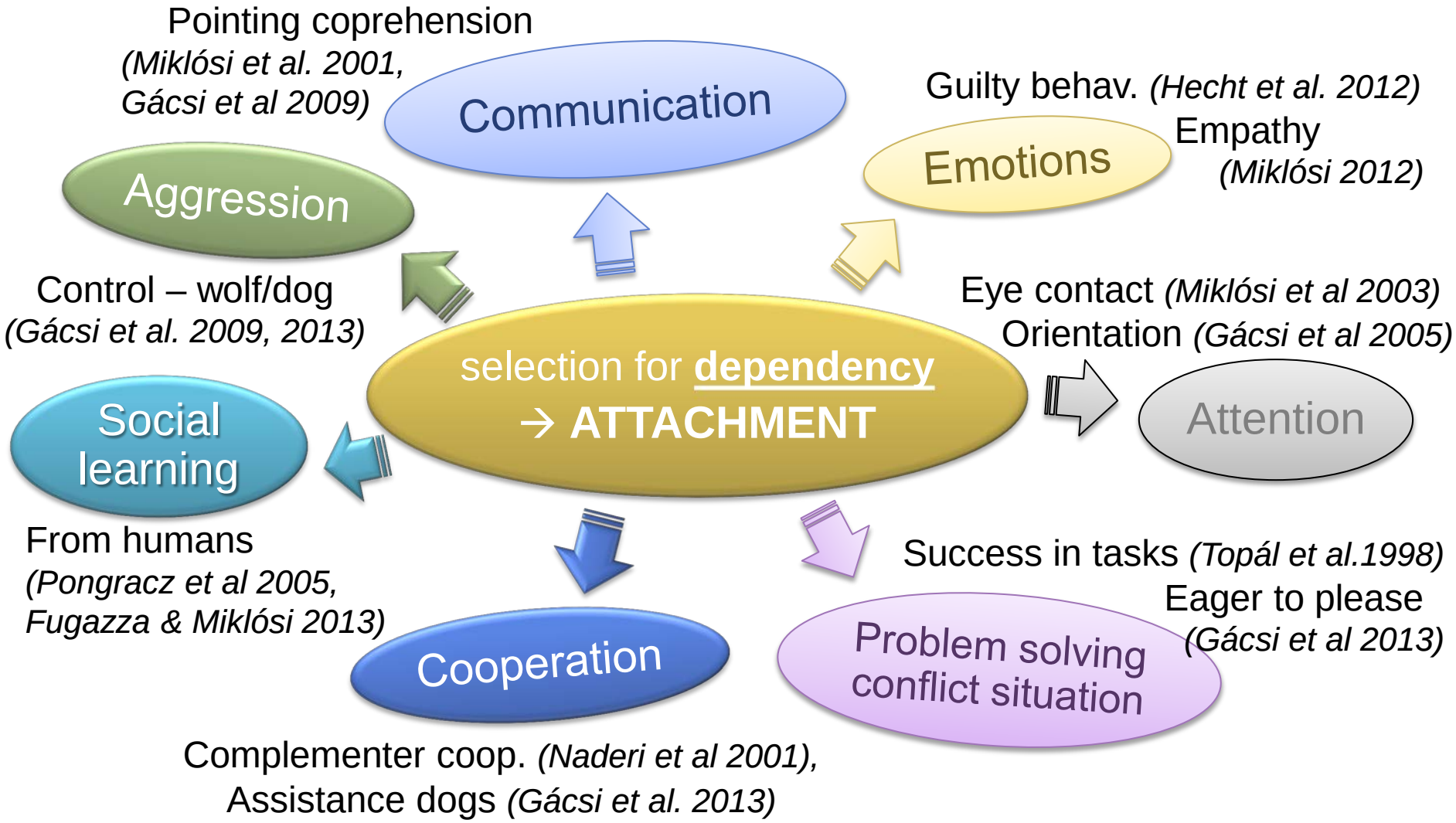
Dog-wolf comparative studies

Hand raising + extensive socialisation of several generations of wolf pups…

… to reveal species-specific differences → due to adaptation to the anthropogenic environment

No attachment/social support in stress

Impacts, connections, consequences



Cooperative(?) problem solving

Dog – wolf comparison (inhibited trial)

Specific differencies

Initialisation of communicative interaction

Some aspects of **social competence**

Interspecific communitation
→ window for cognition

Domestication

selection for enhanced abilities to fit in the human comm. system

adjust behaviour to ‘attentional cues’ provided by humans (Virányi et al. 2004, Gácsi et al. 2004)

’understand’ human pointing signals (better than chimpanzees or wolves) (Gácsi et al. 2009)

The dog – as a model

D has already been proposed to be a promising model for studying several complex phenomena related to humans:

- specific social behaviours such as attachment
  (Scott & Sewart 1973, Topál et al. 2009)
- some human socio-cognitive abilities
  (Hare & Tomasello 2005, Miklósi et al. 2007, Topál et al. 2009)
- genetic basis of certain human illnesses
  (Overall 2000, Héjjas et al. 2007)
- in human-robot interaction research
  (Jones et al. 2008, Kovács et al. 2009, Syrdal et al. 2010, Miklósi & Gácsi 2012).

SR: why dogs – why not humans?

Psychology ➡ human behaviour

?

Humanlike behaviour

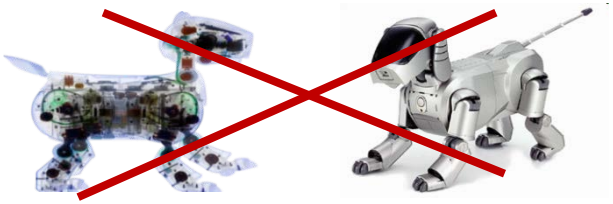
Advantage

- familiarity
- 'same' abilities

Against (pretending)

- disappointment (unfulfilled expectations)
- 'uncanny valley'

embodiment + behaviour ➡ **function**



Doglike behaviour

Advantage

- social skills
- *interspecific* comm.
- attachment to H
- personality

Against

- different body shape
- different abilities
- different comm.

Use diff cues + context

High demand for assistance robots

Function + social competencies!

Growing number of eldery people

- physical and mental problems
- unable to supply themselves

Growing demand for nursing

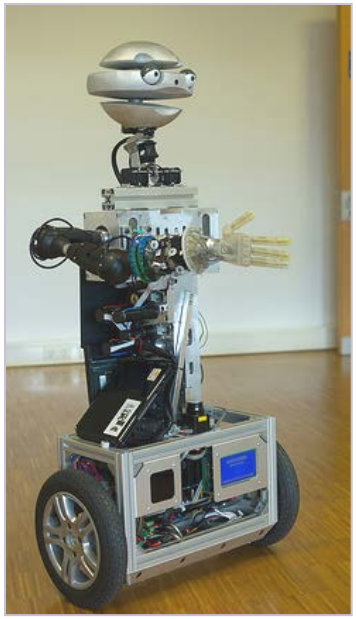
- educated workers?
- privacy?

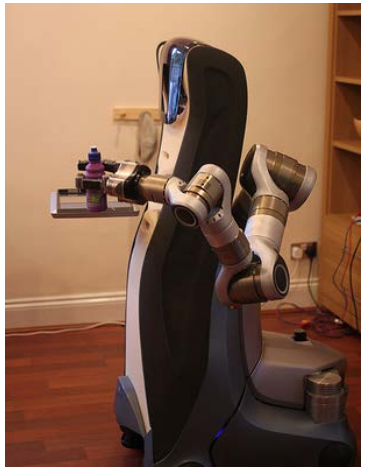
Use of assistance robots in nursing homes

So what's wrong with them?

SR → task + companion

autonomously,
on the long run…?





Drawbacks - problems

Elderly people don't like robots…

- Robots can be disturbing
- People don't know how to use them (and don't want to learn it)
- Individual-specific relationship?
- Long term relationship?

Companion → resemble a living being

H-R interaction → *interspecific*

Robot – dog parallels

most successful companion → the first human ”product”

→ not created but heavily formed by humans for different functions + social abilities

- Special type of partnership (some bond + asymmetry)
- Effective communication + cooperation with humans in spite of different embodyment and capacities (cannot speak, no face)
- Owners are satisfied in spite of dogs’ deficiencies
- Humans attribute personality & emotions to dogs: basic + jelousy, guilt …

1. successfully performing the actions necessary for their specific function,
2. showing convincing social/communicative abilities & attachment

Studies so far….

On dogs

- PERSONALITY dogs & owners
- PROXIMITY → when not used
- EMOTION EXPRESSION
- FETCH & CARRY action sequence, proximity, orientation
- PROBLEM SOLVING social reference, communications
- SIGNALLING & LEADING 'hearing robot', monitoring syst.

On robots

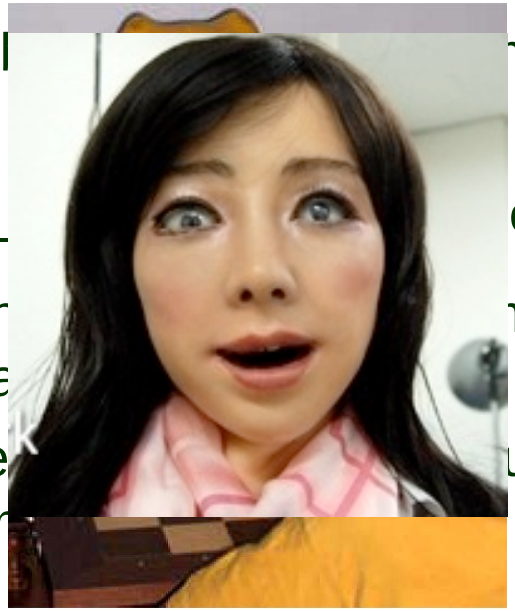
- ATTACHMENT user/stranger
- EMOTION EXPRESSION face?
- FETCH & CARRY action sequence, proximity, orientation
- PROBLEM SOLVING social reference, communications
- SIGNALLING & LEADING 'hearing robot', monitoring syst.
- Dog–robot–human SWARMS

Emotions → facial expressions vs social behaviours

Non-humanoid robots?

- facial expressions?
- no need for face/head (but Icat)
- Uncanny valley effect

Attril nals?



The em to:

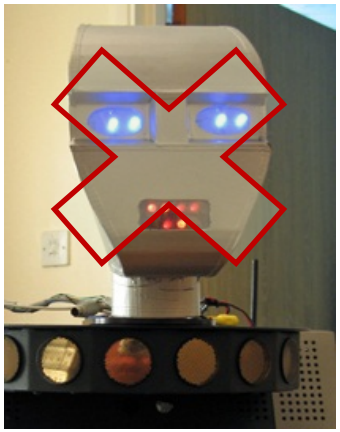
- sh mans ca
- re uma en

Face → not the best/only solution!

Social robot → new species

Human-robot interaction → interspecific

Basic behaviours corresponding emotions



Inner states

1. **joy**
2. **fear**
3. **sadness**
4. **anger**
5. ***neutral***

1. Set of dog behaviour elements (”capacities”) → movement & speed, posture, position of body, head, tail…, and vocalisation for each inner state

2. Applying the relevant/applicable ones (or adapting them) to a specific robot → different embodyment + capacities = different elements!

3. Making short video clips with both a dog and the robot for all 5 emotions (without any context)

4. Evaluation: viewers completed questionnaires

Expressive behaviours: Robot vs. Dog

People-bot robot

- developed by the Wroclaw Univ. of Tech.
- move, turn, lift one hand, move fingers

Dog

- malinois, male, 4-year-old, trained,
- erected ears, long tail

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Behaviours related to sadness

	DOG behaviour	ROBOT behaviour	Vocalization
JOY	comes closer	comes closer	high-pitched, staccato
	wags his tail high	lifts its arm, moves fingers	
	sidles	partly spins	
FEA	approaches crawling,	comes closer	–
	hanging ears, licks lips	backs	
	goes away	turns away, goes away	
SAD	sits down, lies down	backs, turns away a little	low-pitched, long-drawn
	turns his head down	lets its arm down	
ANG	barks snarling	approaches	low-pitched, loud, staccato
	wags his tail	moves its arm high	
ATT	turns toward the camera	turns toward the camera	–
	approaches, stops, gazes	approaches, stops, orients	

Joy, sadness, fear, anger, or none?

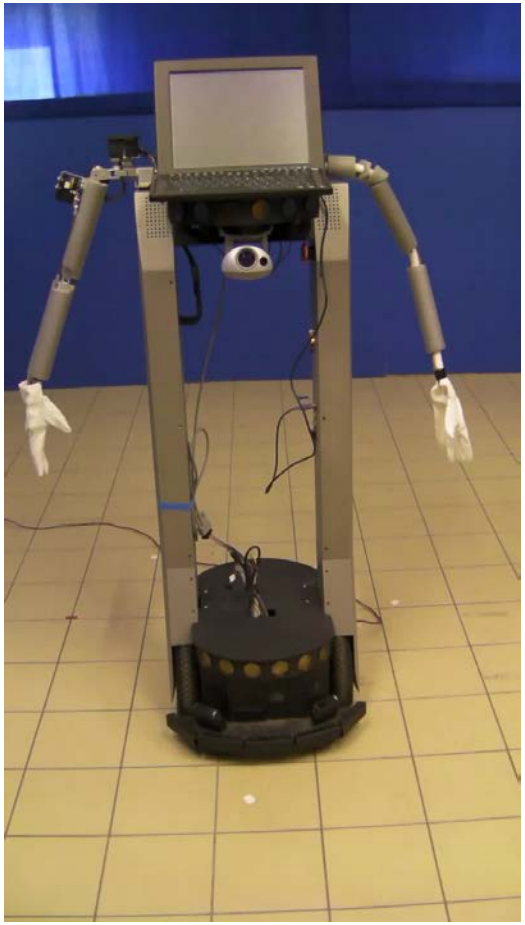
Questionnaire study

Open ended Qs

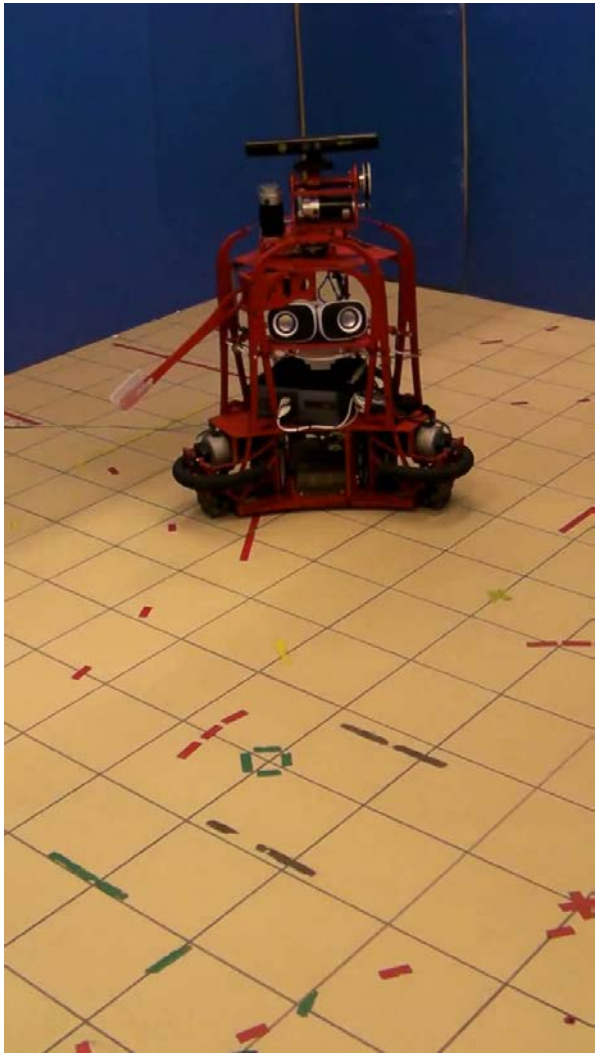
- Attribution of emotions to both dog and robot

Forced choice Qs

- Successful match of all robot videos with the correct emotional states
- Experience with dogs had no effect



Adaptation to different embodiments



Attachment → behavioural differentiation

Greeting

Different responses to user/familiar person
vs. unfamiliar person

Attachment → behavioural differentiation

Greeting

Different responses to user/familiar person
vs. unfamiliar person

Attachment → behavioural differentiation

Familiar person

Greeting in an office

Unfamiliar person (visitor)

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Cooperation → assistanance dogs

Double criteria: technical service + social role (companion)

- Effective communication and cooperation with humans despite different anatomy and capacities
- H understand without formal learning
- D understand even Hs with decreased abilities
- Attachment + social support

Modelling the dog's **motor** behaviour

Manipulation skills

- \+ Way of grabing
- \+ Target setting

BUT

- – *No social behaviour*
- – Human speech

Bio-inspired Assistive Robotics: Service Dogs as a Model for Human-Robot Interaction and Mobile Manipulation

H Nguyen & CC Kemp 2008. Healthcare Robotics Lab, Georgia

AN EXAMPLE OF SUCCESSFULLY GIVING A VERBAL COMMAND

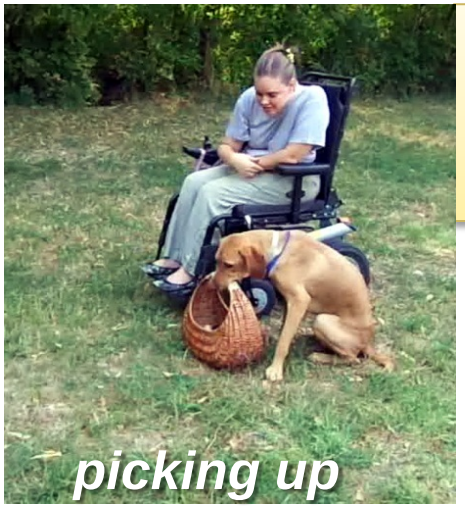
Speaker	Phrase
User	Robot arm give
Robot	I heard robot arm give. Is this what you said?
User	Yes
Robot	OK

Fetch & carry

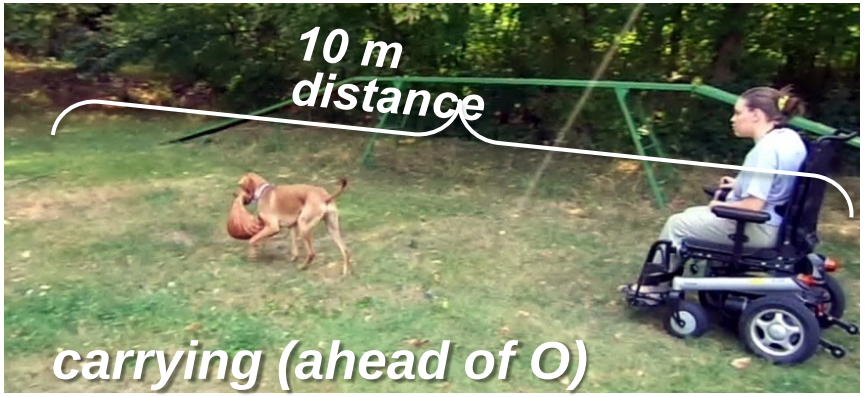
	NOVICE	EXPERIENCED
OWNER	8	8
WHEEL-CHAIRED owner	8	8

- 32 dog-owner dyads → trained assistance or therapy dogs tested with O
- Training → principle 'eager to please' → comprehending O's communication
- N vs. E → same training but different experiences (duration of working together)
- Individual differences in performing tasks

Sequences of the task



1. Picking up
2. Carrying
3. Placing



Analysis

- verbal instructions
- joint attention
- gestures
- dog's relative position
- duration of tasks

Owner can't touch dog or basket, otherwise free → spontaneous comm.

Results – characteristic behaviours

Picking up (interaction initiation)

- Joint attention → all dyads (spontaneously/by attracting attention)
- Pointing → all Os (some with head)
- Verbal comm → correlation with duration **+** novice needed more

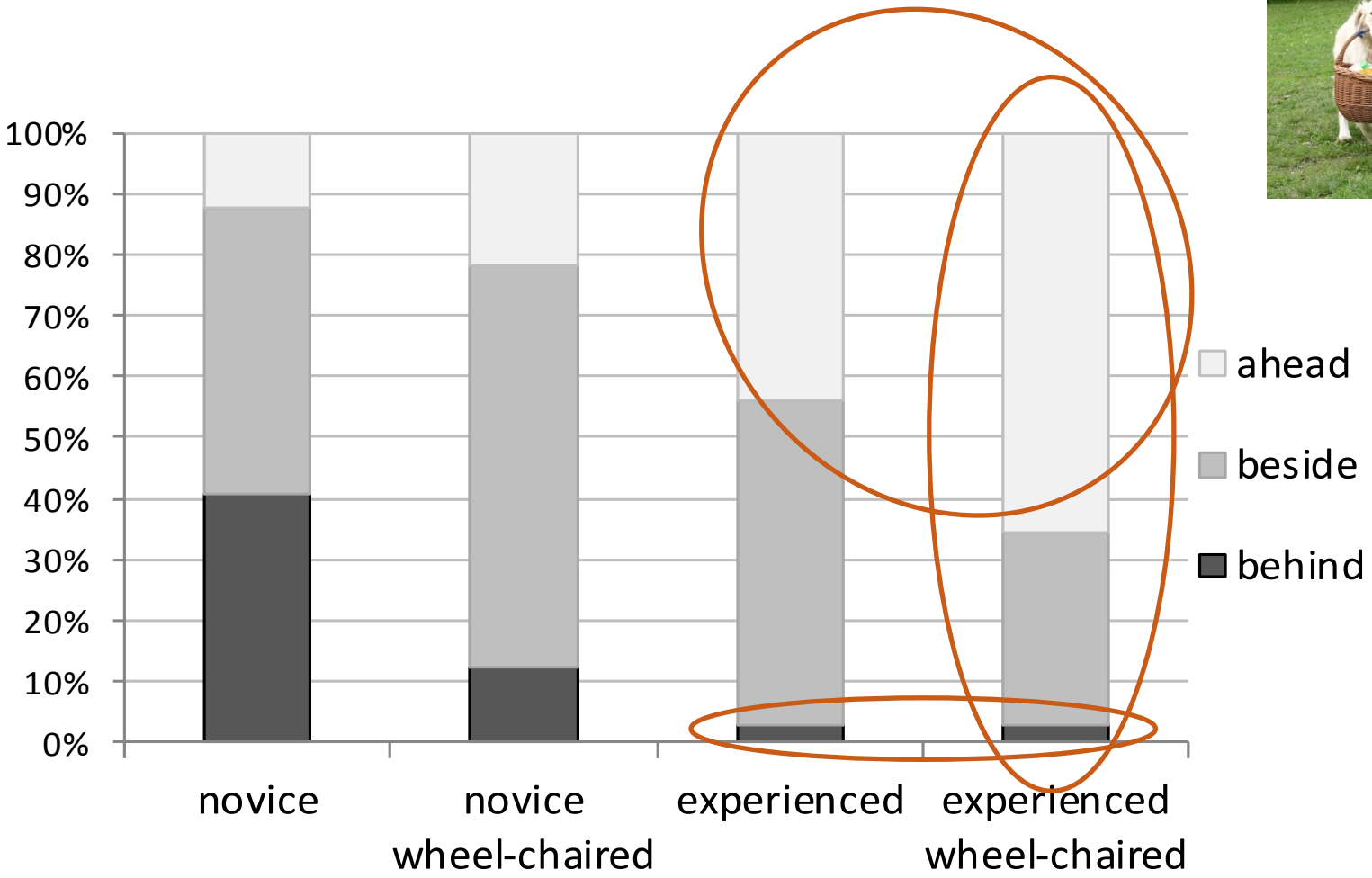
Carrying

- Joint attention & Pointing → typical but not in all dyads
- Verbal communication → novice needed more + for wheel-chaired Os the task took more time, but they did not talk more

Placing

- Joint attention & Pointing → typical but not in all dyads
- Verbal communication → correlation with duration of task → novice wheel-chaired group needed more time and instructions

Position of dog during carrying



Fetch & carry → different embodyments

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Wroclaw University – FLASH

Fetch & carry → different embodyments

BME/ELTE – MOGI Robi

Fetch & carry → different embodyments

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Univ. Bamberg – Pleo

Insoluble task – unforeseen difficulties

Two types of response:

- latency of look at O + E
- approaching O
- vocalization
- displacement behav. *(yawn, stretch, paddle, shake, scratch, licks lip)*
- fetching other object
- duration of looking for basket

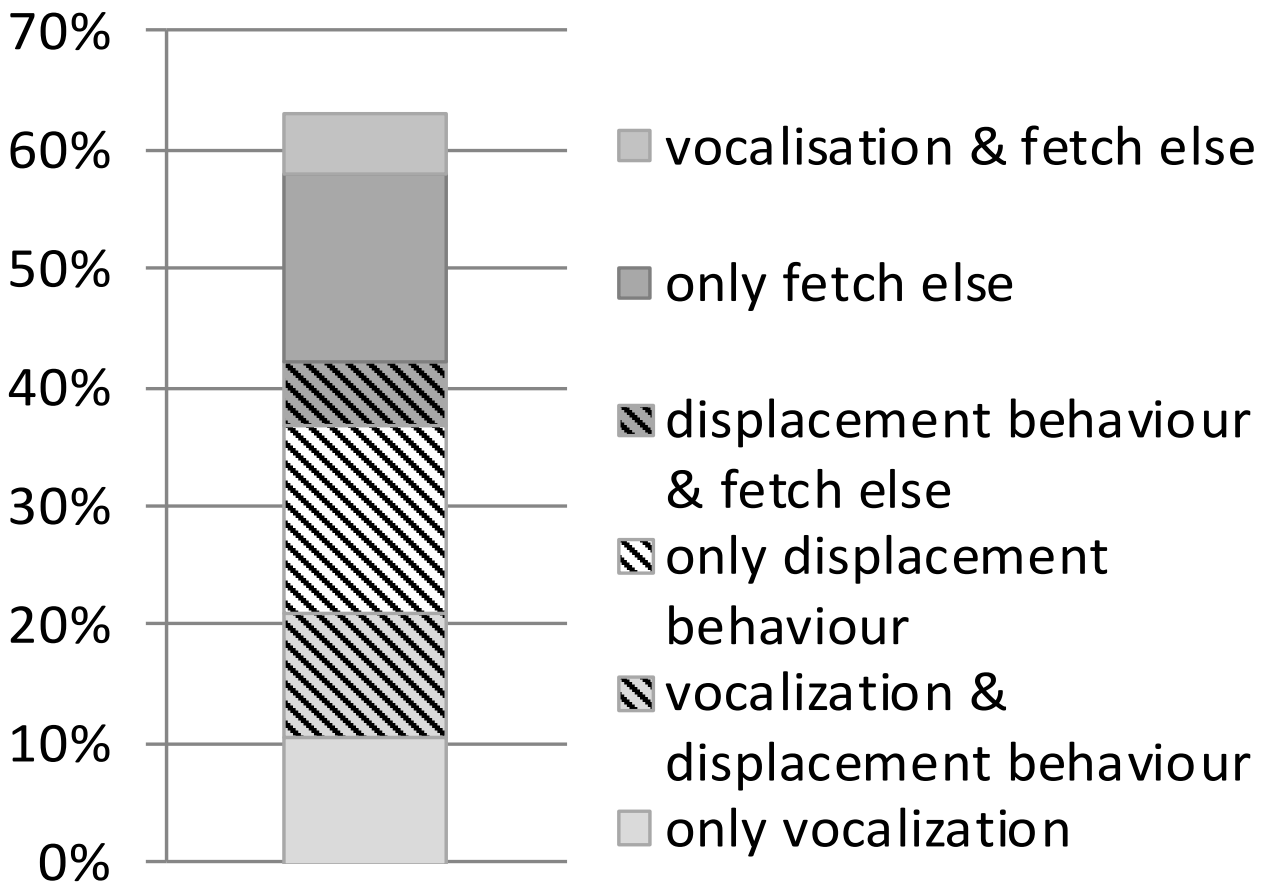
help the owner to realize the problem

Communicative & displacement behaviours

Most dogs were looking for basket for long!

busy appearance

attenuate O's disappointment



Proportion of dogs that vocalised, exhibited displacement behaviour or did both

Insoluble task – non-cooperative human

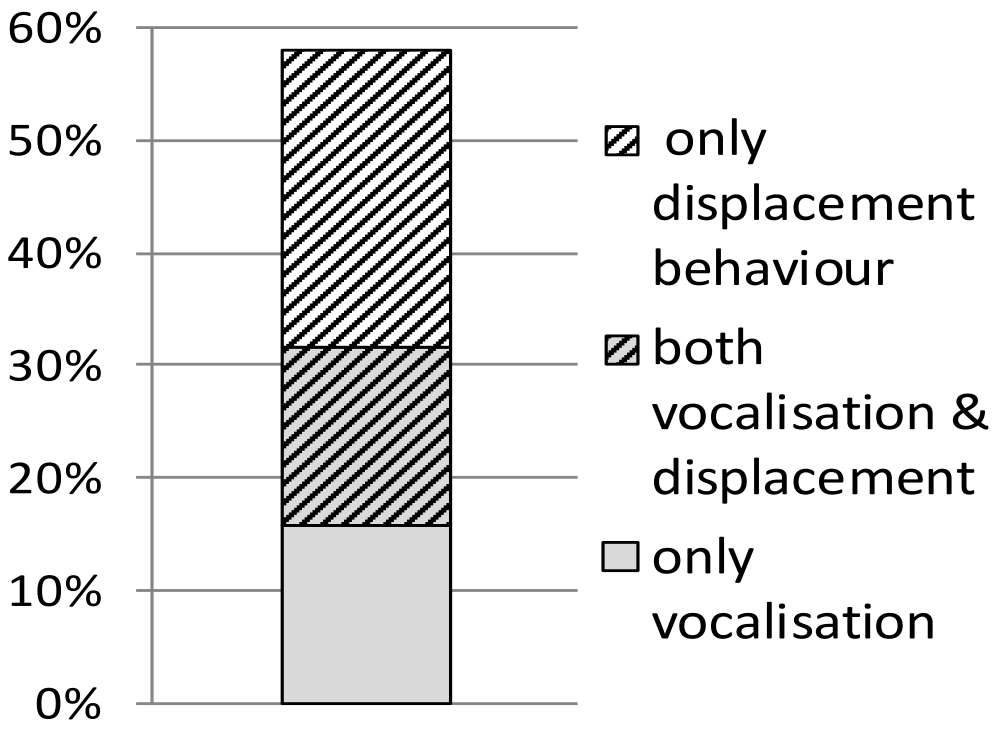
Analysis

- latency of look at O
- looking at E
- approaching O
- vocalization
- displacement behav. *(yawn, stretch, paddle, shake, scratch, licks lip)*
- fetching other object
- duration of pulling
- duration of chewing

Communicative & displacement behaviours

ALL dogs pulled the basket strongly

Dogs do not give up easily if they face a "seemingly" insoluble task.



Proportion of dogs that vocalised, exhibited displacement behaviours or did both when E did not hand over the object

Hearing dog/robot → signalling & leading

DOG – OWNER interactions

- behaviour description (attention getting, leading)
- typical behaviours
- from this set adapting the relevant actions
  → adjust to the robot's capacities + embodyment

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Hearing aid → signalling

Hearing dog – signalling & leading (door)

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Hearing dog/robot → signalling & leading

DOG – OWNER interactions

- behaviour description (attention getting, leading)
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- flowchart → algorithm

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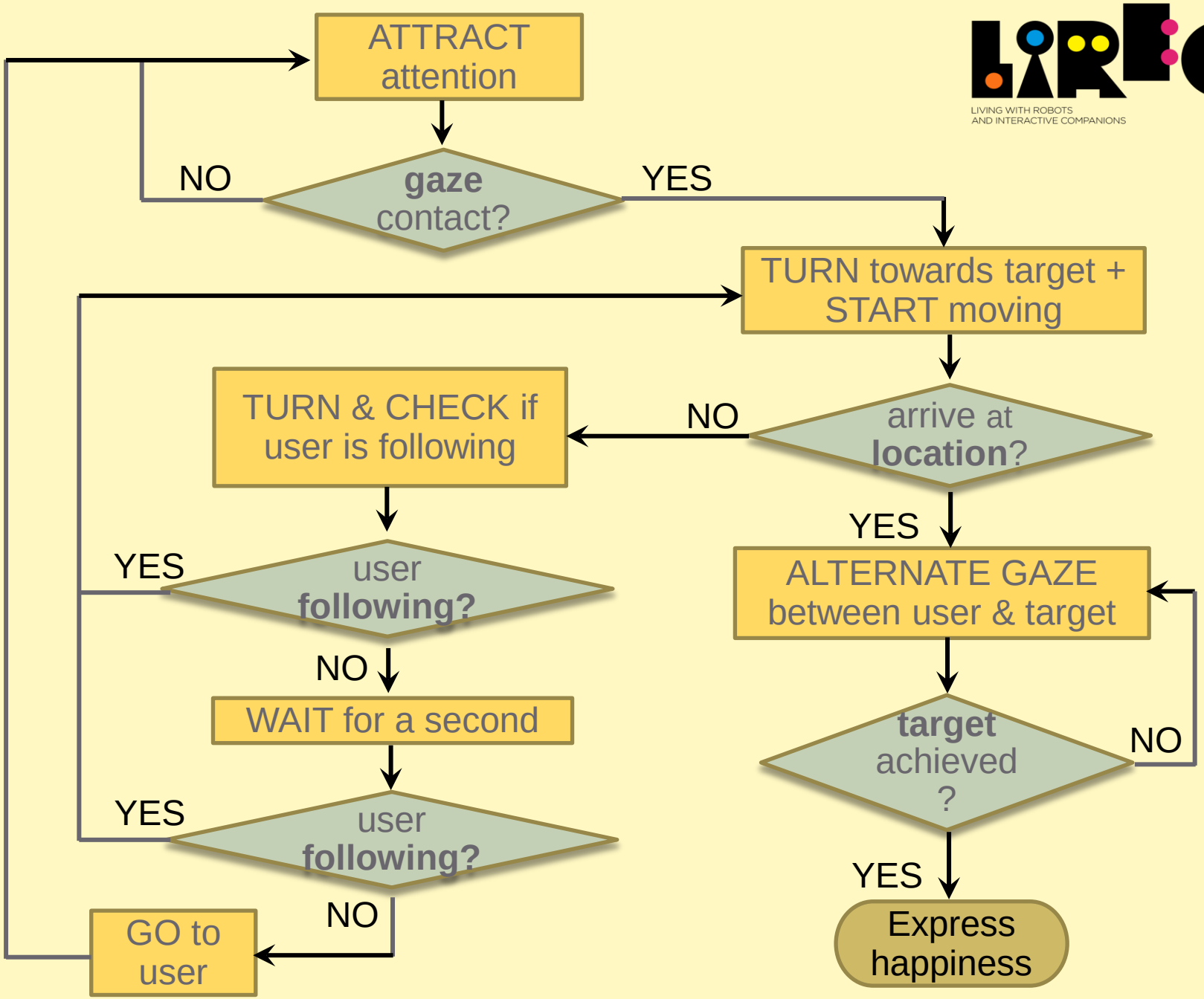

ATTRACT attention
gaze contact?
NO
YES
TURN towards target + START moving
arrive at location?
NO
TURN & CHECK if user is following
YES
ALTERNATE GAZE between user & target
user following?
YES
NO
WAIT for a second
user following?
YES
NO
target achieved ?
NO
YES
GO to user
Express happiness

’Hearing’ robot – signalling & leading

Wrocław University of Technology

Mariusz Janiak,
Robert Muszyński

Hearing dog/robot → signalling & leading

DOG – OWNER interactions

- behaviour description (attention getting, leading)
- typical behaviours
- from this set adapting the relevant actions
  → adjust to the robot's capacities + embodyment
- flowchart → algorithm

ROBOT – USER interaction

- Test success → naive subjects could interact with robot in relevant social context → answer questions + we observed their behaviour during interaction

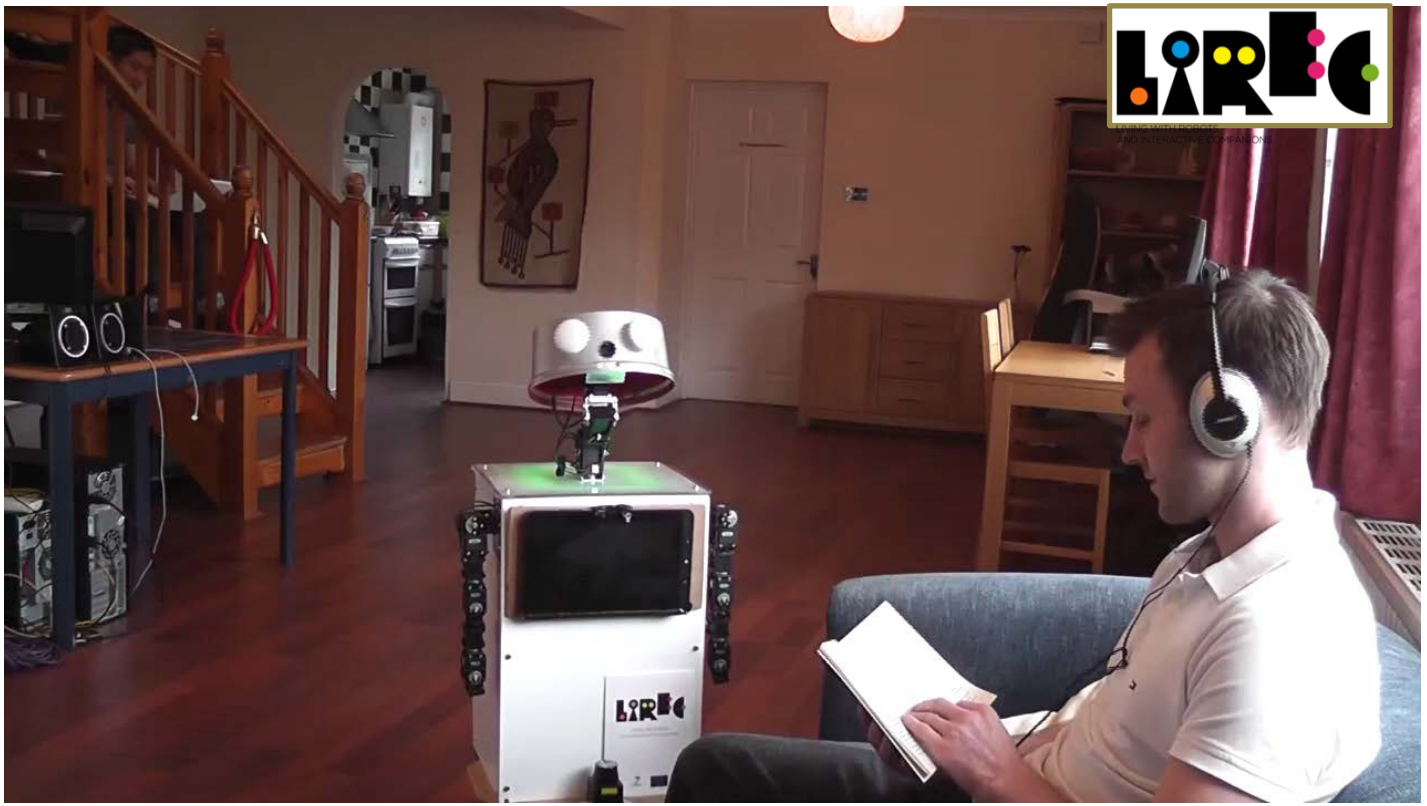
Signalling → leading → pointing

Readability of dog inspired visual communication signals → untrained subjects

preprogrammed + controlled by a wizard → directly implemented the dog responses

able to lead naiv subjects to the sound sources

correctly interpret R intentions → head + gaze



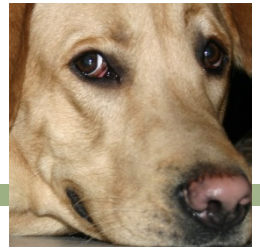
K. Dautenhahn → *Kheng Lee et al. 2013*

University of Hertfordshire

Porter dog/robot → leading

P. Korondi – Budapest University of Technology, MOGI

Porter robot
leading behaviour



Conclusion

- We suggest considering the human-robot interaction as an interspecific interaction, and thus using a non-human species, the dog as a natural model for developing believable and efficient social behaviour of robots.
- We can identify simple basic behaviours available even to a mechanical-looking embodiment, which enable robots to show complex and variable repertoire in social interactions with humans.
- Assistant dogs' social responses (cooperative and communicative behaviours, and problem solving strategies) could inspire the development of the relevant functions and social behaviours of SR.
- Service robots should communicate their inability to solve a problem using simple behaviours, and/or could show displacement behaviours rather than simply not performing the task.

Acknowledgements

KUTYÁVAL AZ EMBERÉRT

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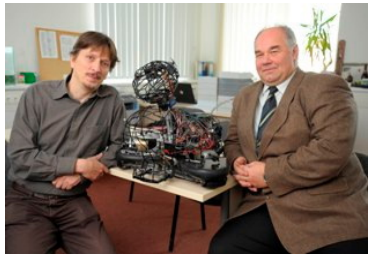
Knowledge into Action

MOGI



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