Effects of Saliency of an Agent's Input Information on Estimation of Mental States toward the Agent

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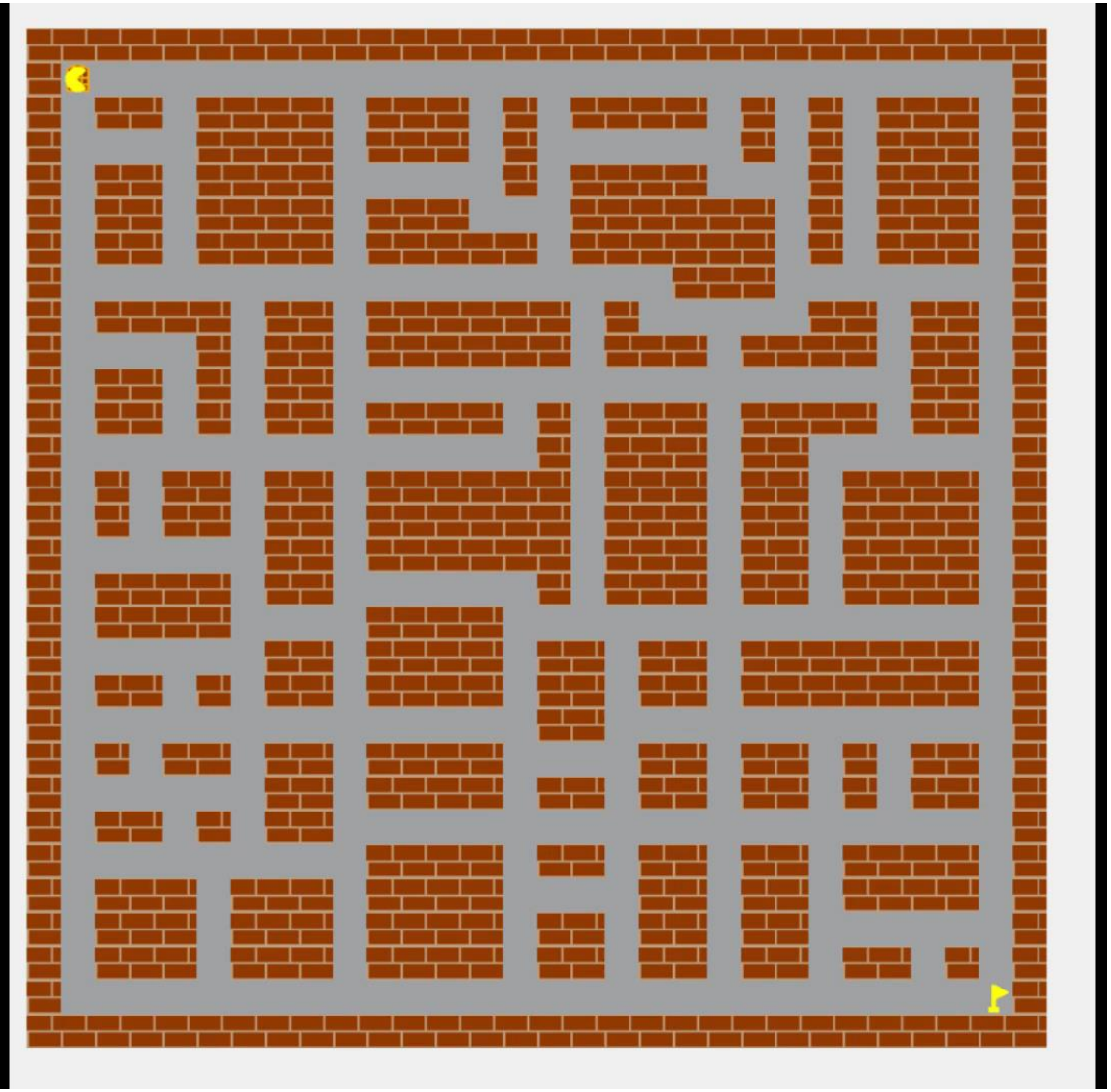
Short Biography

- **Yuki Ninomiya**
  - field of study
    - Cognitive Science, Cognitive Psychology
    - problem solving, insight, reasoning
  - Affiliation
    - Global Research Institute for Mobility in Society (GREMO), Institutes of Innovation for Future Society (InFuS), Nagoya University, Japan
  - Recent Work
    - Does the finder of alternatives intentionally seek information irrelevant to the trained procedure? (in press) CogSci2023
    - Differences in the distribution of attention to trained procedure between finders and non-finders of the alternative better procedure (2022) *Frontiers in Psychology*
    - How impressions of other drivers affect one's behavior when merging lanes (2019) *Transportation Research Part F: Traffic Psychology and Behavior*

Introduction

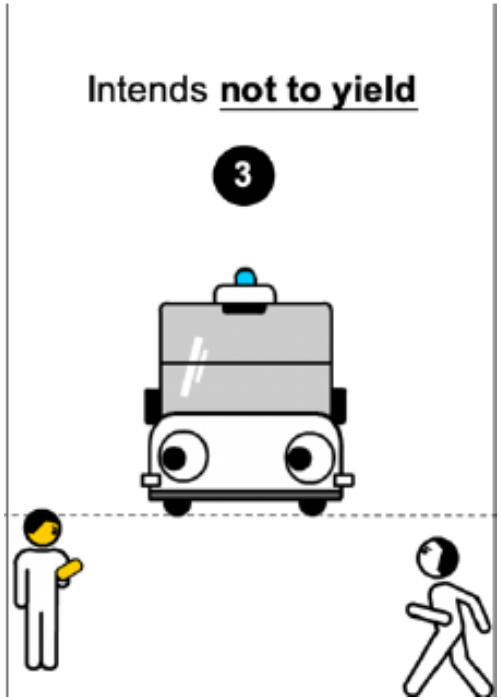


- Humans can estimate the mental states of supposedly mindless agents
  e.g. Robot vacuum felt puzzled.

- Estimation of mental states helps simplify the mechanisms of complex agent behavior, and is useful for prediction and understanding (Epley, Waytz, & Cacioppo, 2007)
  e.g. Robot vacuum felt puzzled.
  ＝Ease understanding of situations in which the robots' goals will not be achieved.

Introduction

- Failure to estimate mental state can lead to serious accidents.



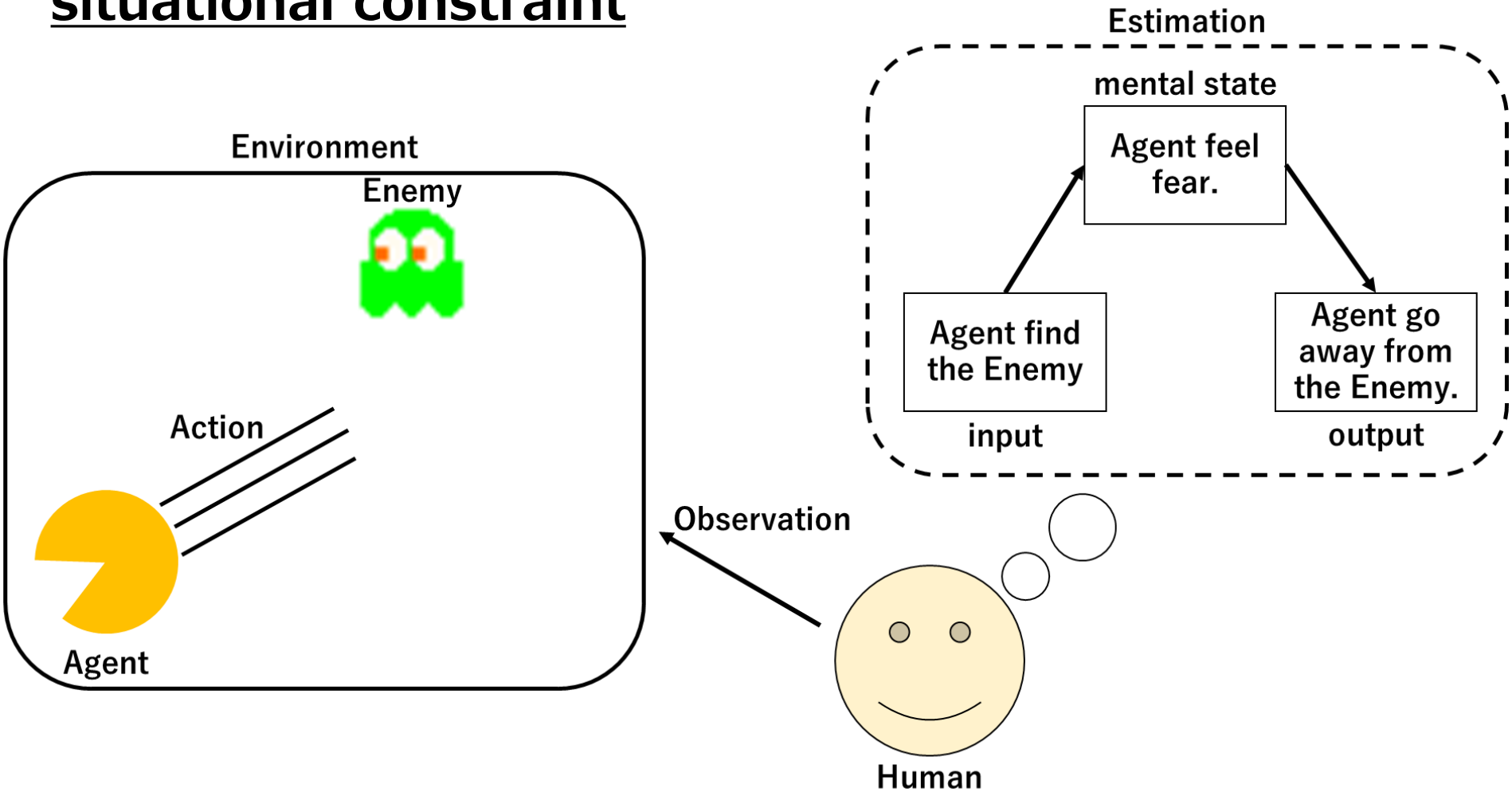
- This experiment tested whether attaching artificial eyes on an automated vehicle would result in a smooth crossing.
  - The attaching eyes were intended to infer intention (mental state).
- Even in the condition where the eyes were turned to someone other than the crosser, presenting no intention to yield to the crosser, 24.44% of the participants decided to cross the road.
  - About 25% of participants incorrectly estimated agents' mental state (cars' intention)

(Chang et al, 2022)

- How can we make them feel the correct mental state?

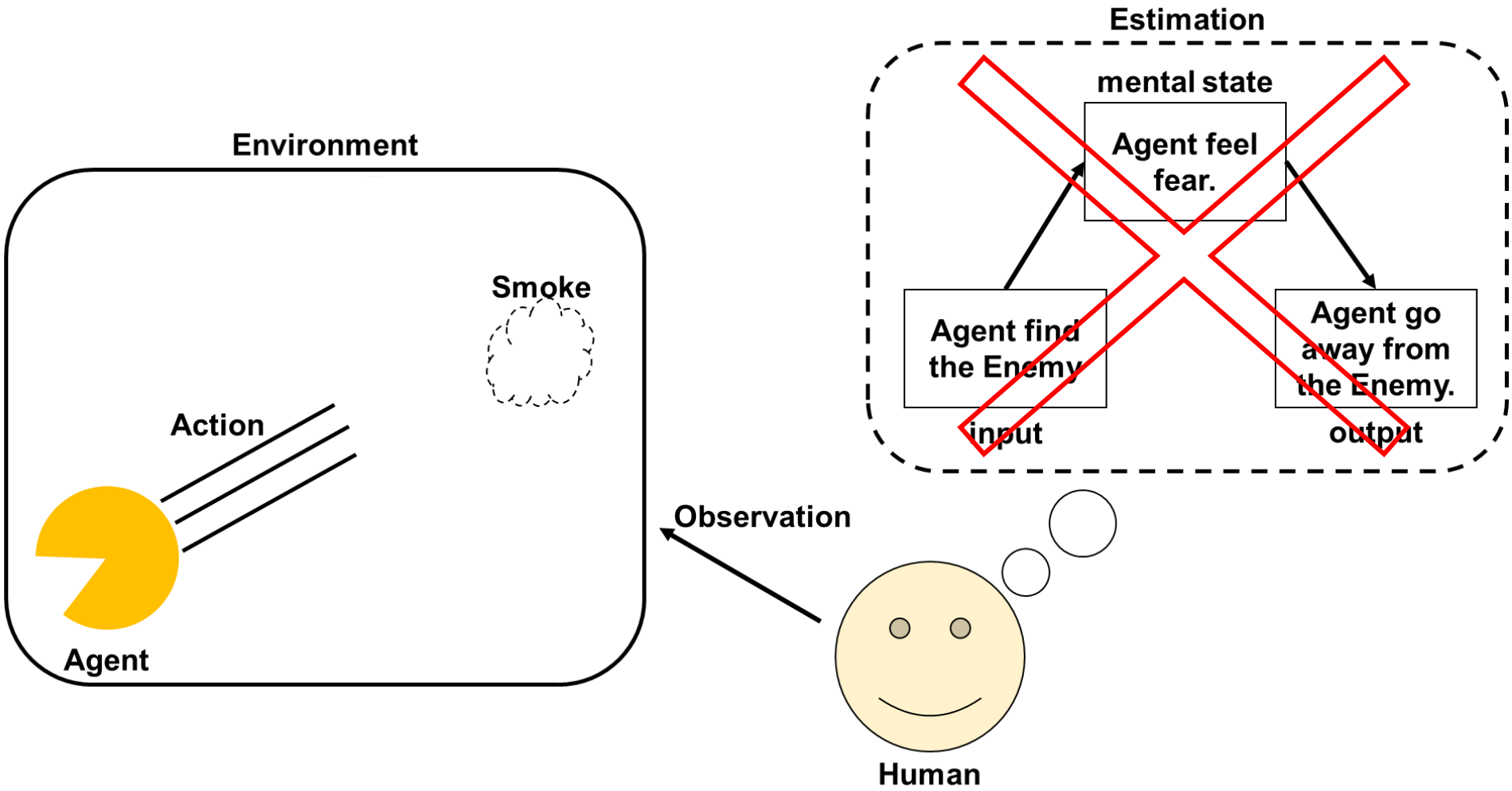
Introduction

- Estimation of mental states is based on information about **the observable action** and **the environment as a situational constraint**



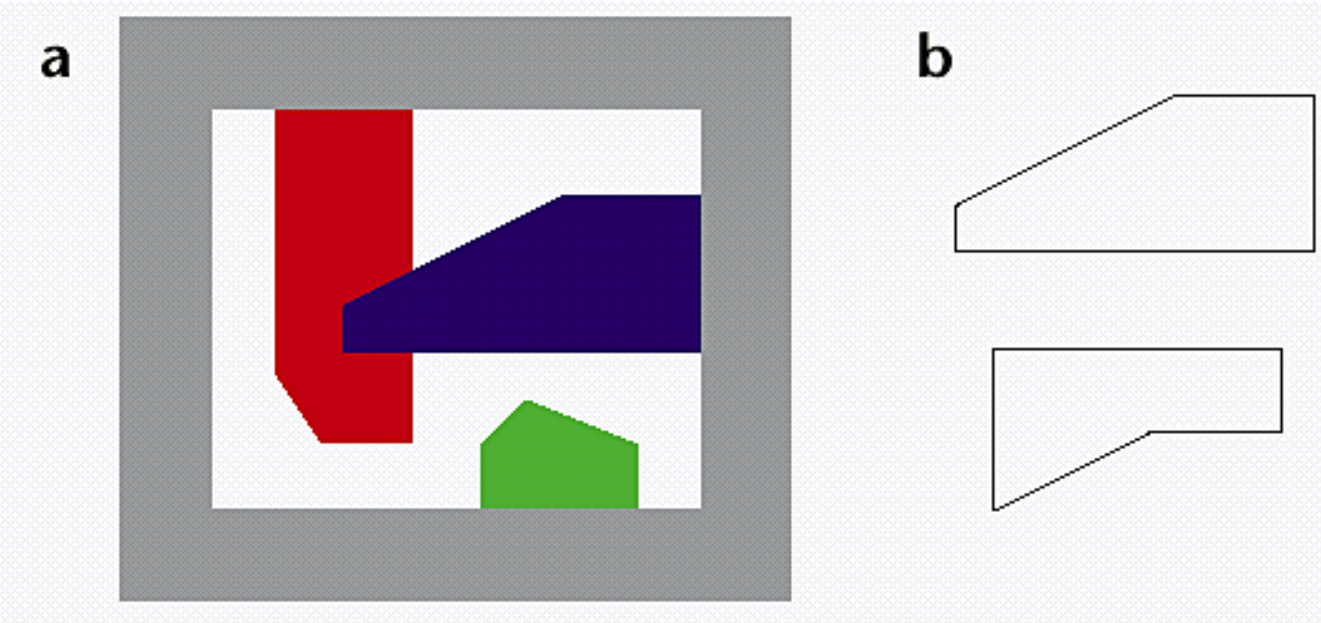
Introduction

- Estimation of mental state leads to errors when the observer is not aware of the agent's input



Introduction

- Salience is a stimulus property that indicates how noticeable a stimulus is compared to its surroundings.

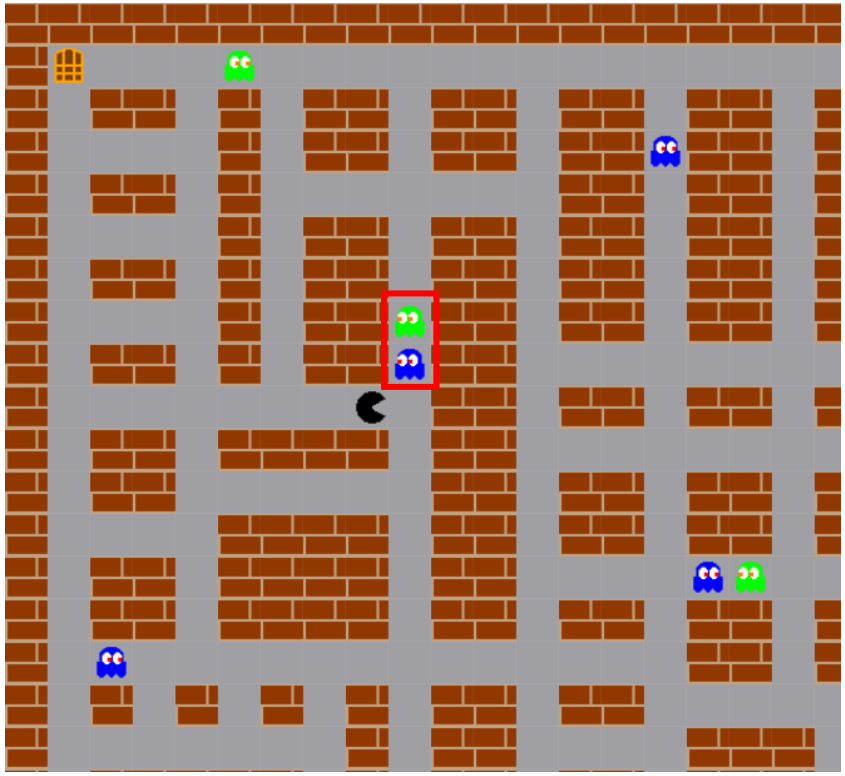


(Rubin, 2001)

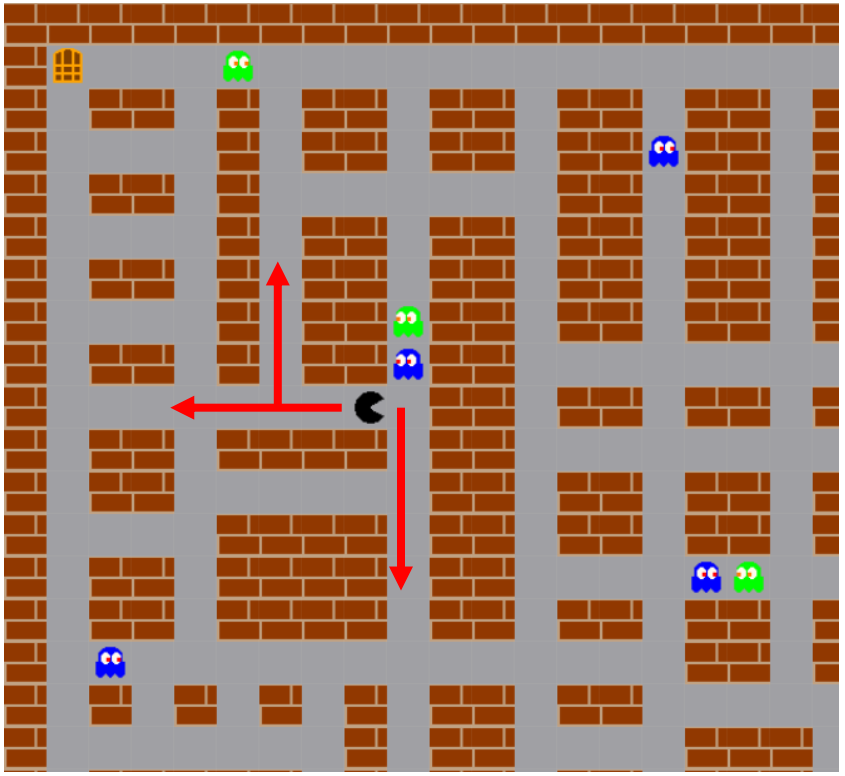
- Even in the case of estimating the agent's mental state, less salient information may be easily missed

Introduction

- Tasks asking participants to estimate what Pac-Man is fear of.



- Number of enemies
  - information of high salience



- Number of escape routes
  - information of low salience

Research Question

Objective : Examining the effect of saliency of input information on the accuracy of the estimation of mental states.

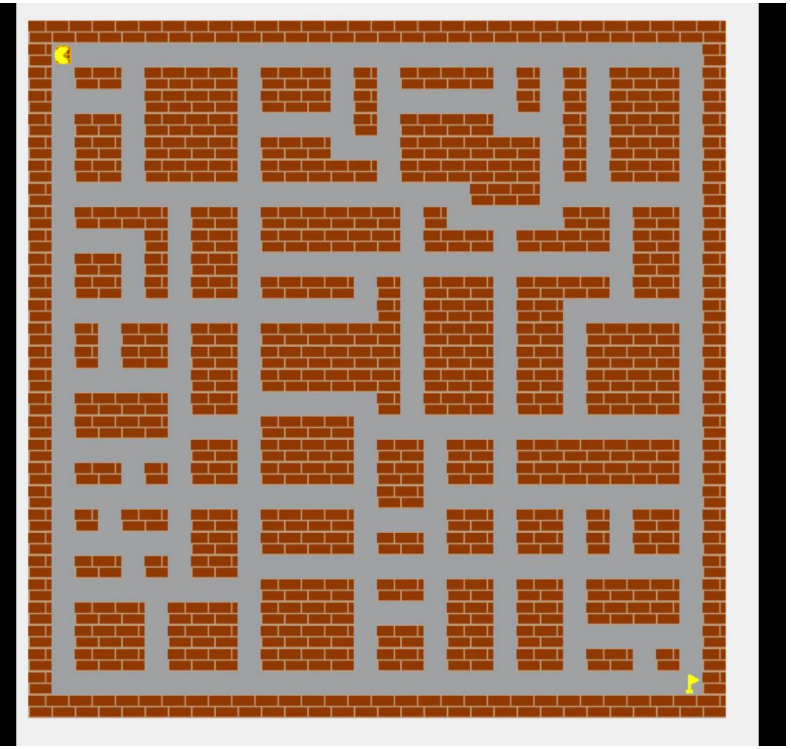
RQ1:Can an observer correctly estimate an agent's mental state even when the agent is using low salient information?

RQ2:Is there a discrepancy between the results of the estimation of mental status and the verbal report?

- In previous studies, verbalization of thoughts is known to focus attention on high salience information(Ball et al.,2015; Schooler et al., 1993)
- Low salient information may be easily ignored in the case of verbal reports

Method

Observation → Estimation → Verbal report



- Phase where participants estimate their mental state through observation.

Conditions

Enemy : input is the number of enemies

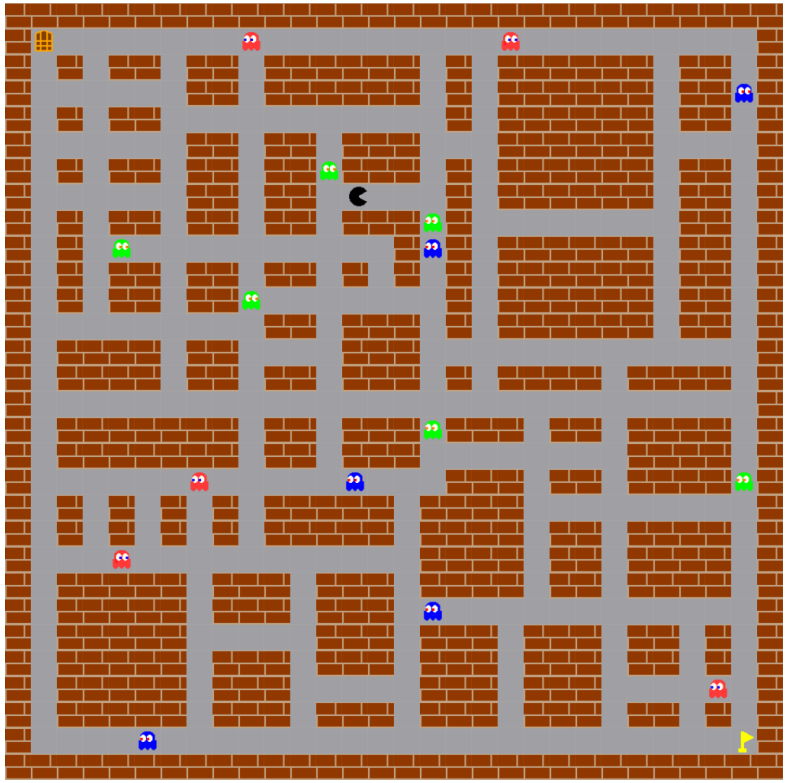
Route : input is the number of escape routes

Enemy route : input is number of enemies and number of escape routes

Control : Input is random

Method

Observation → **Estimation** → Verbal report



- Phase to measure performance of the estimation of mental state

Instruction

- How much fear do you think the agent feels when the agent is in this location?
- Please use the slider to answer the agent's level of fear on a scale of 0 to 100.

Method

Actual use(Japanese ver.)

_____ならば恐怖を感じる

Image in translation

If _____,
then Agent feel fear.

- Phase in which participants verbally report the information they were focusing on during their estimation of mental state.

Instruction

- Please answer in the form of "If ___, then Agent feel fear" about what situations the agent felt fear.

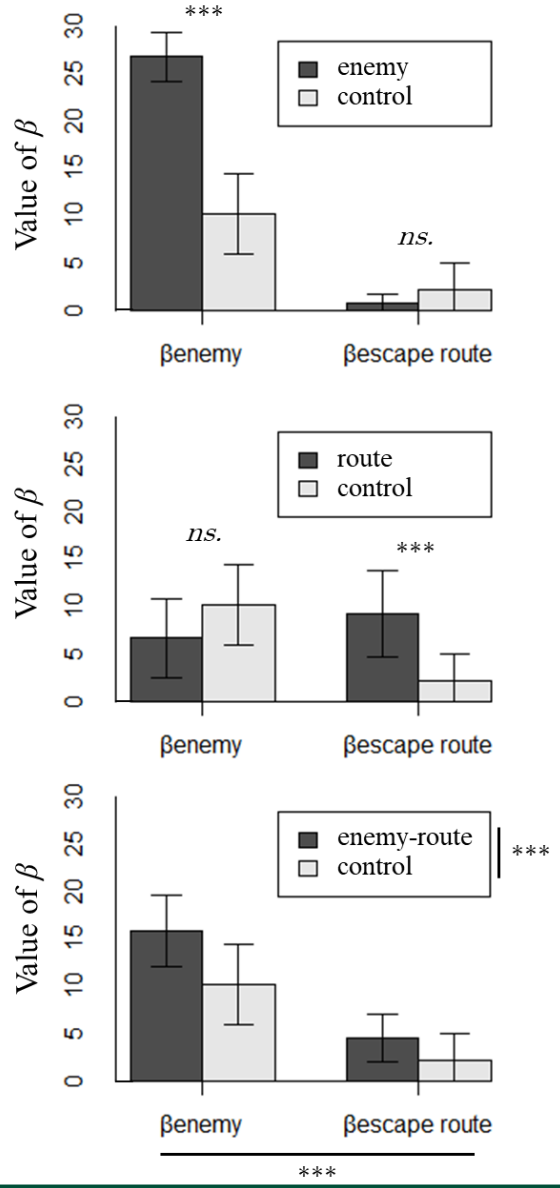
Results

- Making Index
  - First, the following multiple regression equation was calculated for each participant.
    - The explanatory variables is the environmental information in the evaluation images (Specifically, number of enemies and routes).
    - The explained variable is the participant's fear rating.
  - We used β as a measure of how much attention the participants paid to each type of information when estimating the agent's mental state.

$$Fear = \beta_{enemy} * number\_of\_enemies + \beta_{escaperoute} * number\_of\_routes + e$$

Results

- To examine whether participants correctly focused on each information, we compared each condition to the control condition.
  - Normally, if the participants correctly used the information, the corresponding *β* for each condition should be higher than in the control condition
- The results showed that in all conditions, the β corresponding to the input information used by the agents was higher than in the control condition
  - Importantly, there were no significant differences for information not input by the agent.
    - routes in the enemy condition
    - enemies in the route condition
- Compared to the random condition, <u>all conditions were correctly estimated focusing on the corresponding information</u>.



Results

- We coded participants according to whether their rules of the number of enemies or escape routes were in the description in the verbal report.

a. Number of participants who described the enemy

	enemy	route	enemy-route	control
Described	27(3.46) ▲	10(-5.26)▽	24(2.34) ▲	20(-0.51)
Not described	0(-3.46) ▽	17(5.26) ▲	2(-2.34) ▽	8(0.51)

b. Number of participants who described the route

	enemy	route	enemy-route	control
Described	1(-4.82) ▽	19(3.25) ▲	13(0.77)	14(0.80)
Not described	26(4.82) ▲	8(-3.25) ▽	13(-0.77)	14(-0.80)

- In the enemy route condition, the results deviated from the estimation of mental state.
  - Not a high ratio of rules regarding routes
- It is possible that the verbalization focused attention on the more salient information and missed the less salient information.

Conclusion

Answer to RQ

A1： People can correctly estimate mental states by focusing on low saliency information.

A2：When asked to verbally report mental states, attention is focused on higher salient information, and lower information is more likely to be missed.

Contribution

- Showing that in simple situations, humans can also focus on low saliency information.
  - Findings showing flexibility in estimation of mental state
- Showing that even if the estimation of mental state is correct, it is difficult to consciously report it.
  - Implications for methods of surveying user evaluations and understanding

Future work(Work in progress)

- Can we correctly estimate the mental state of a more complex agent?
  - When more input information and output relationships must be considered, lower information may be more easily missed.
- Can the estimation of mental states be changed when the agent's system changes?
  - Real systems are designed on the assumption of updating the contents of the system, such as version upgrades.
  - If an agent stops using highly salient input information and starts using less salient information, it may be difficult to fix.
  - Because it is easy to focus attention from low saliency information to high saliency information, but difficult to focus attention from high saliency information to low saliency information.