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Measuring preschoolers' noticing of an unexpected event in Magical Garden with a Teachable Agent using Eye-Tracking

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Introduction

Children who do not develop a number sense (an understanding of amounts, proportions, numbers, and arithmetics) will suffer dire consequences in their future development. Educational games have shown a positive effect on students learning and motivation. Teachable Agents (TA) is a pedagogical digital student designed to motivate and help children's learning process. Preschoolers' social interaction with a TA has unfortunately been scarcely researched. The fact that there is a close connection between top-down control and eye movements means that noticing could be manifested as increased visual attention to an area, which can be recorded by an Eye-tracker. With a sufficient number sense attention will be given towards what is meaningful in a task. In this study, an unexpected event was designed. The unexpected event was tree elevator malfunction in the educational game Magical Garden, which utilizes a TA. The purpose of the unexpected event was that only children with sufficient number sense would detect and notice it. A model of detection was proposed and tested with an eye-tracking experiment "looking back at the correct branch after the elevator had passed the correct branch before it reaches the tree top".

Method

Participants

In this study, 40 preschoolers (21 girls, $M = 4.6$, $SD = .72$) participated. Three preschools were selected by sample of convenience, all of which were located in the south of Sweden.

Design of the experiment

- First, there was a three week phase of familiarization, where the preschoolers played the game Magical Garden on tablets 1-3 times per week with no unexpected events.
- Then the eye-tracking experiment was conducted at the preschools where the children played a minimum of five trials of a specially designed version of Magical Garden (with unexpected events).
 - A trial consisted of four exercises:

Child in charge +	Child in charge +	TA in charge +	TA in charge +
Expected event	Unexpected event	Expected event	Unexpected event

Conclusions

- The noticing of an unexpected event was a novel and successful method of exposing children's level of number sense.
- Preschoolers attend the TA during an unexpected event. Furthermore, they attended the TA more when the TA was in charge, thus they demonstrated an understanding of a social role of being in charge.
- A better model of detection could be constructed from eye-movements such as "look back", "looking at button/thought-bubble", and "anticipation", as well as verbal report such as "it goes wrong", and other non-verbal report such as "looking at the experimenter".

Future research

- Should examine the possibility of creating a new, improved model of noticing in order to capture the whole notion of detecting an unexpected event.
- Should develop, use, and research educational games as operationalized tools and exercises.
- Further research on preschoolers' interaction with TAs is still needed.

Results

- Detecting the unexpected event with a "look back" significantly correlated with performance, $R^2 = 0.138$, $F(1,38) = 6.099$, $p = .018$ (see fig 1).
- Participants looked significantly more at the TA when the TA was in charge as opposed to when they were in charge, $t(39) = 3.66$, $p < .001$, with a 95% confidence interval of $[0.06 - 0.22]$ (see fig 2).
- An explorative correlation analysis found a strong correlation ($r = .5$) between performance and "look at button". In addition, a medium correlation ($r = .41$) between 'anticipate' and 'look at button'.

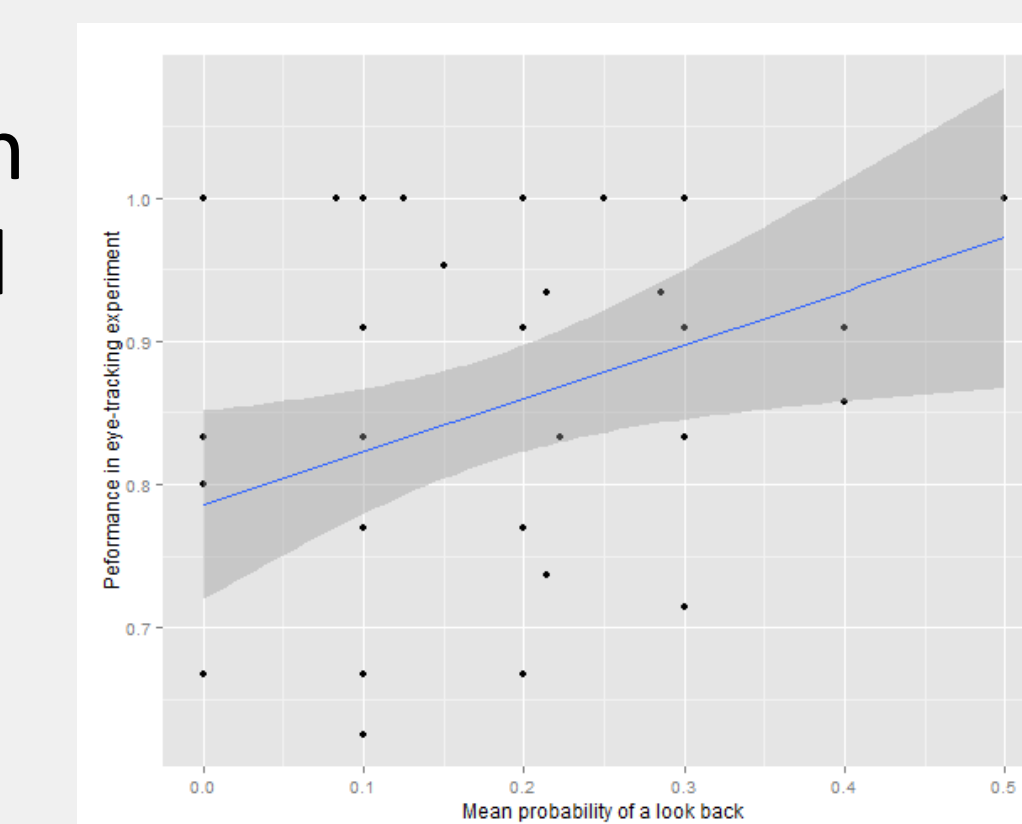


Fig 1. A linear regression line ($r = .37$) of the mean probability of a look back and performance.

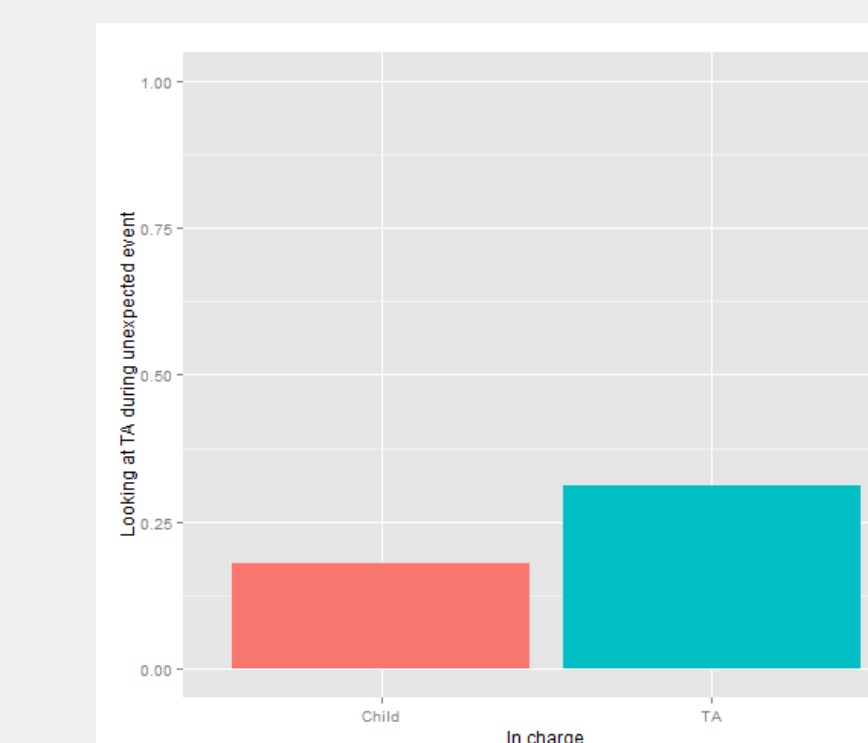
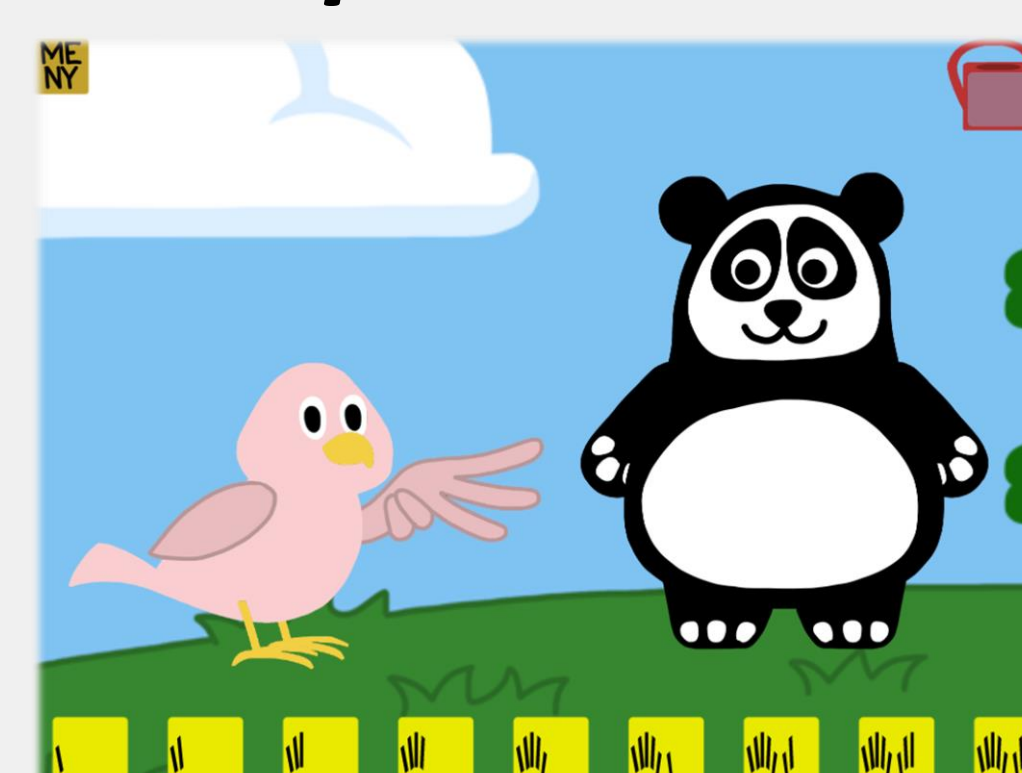


Fig 2. The mean number of looking at TA divided up by who was in charge (Child or TA)

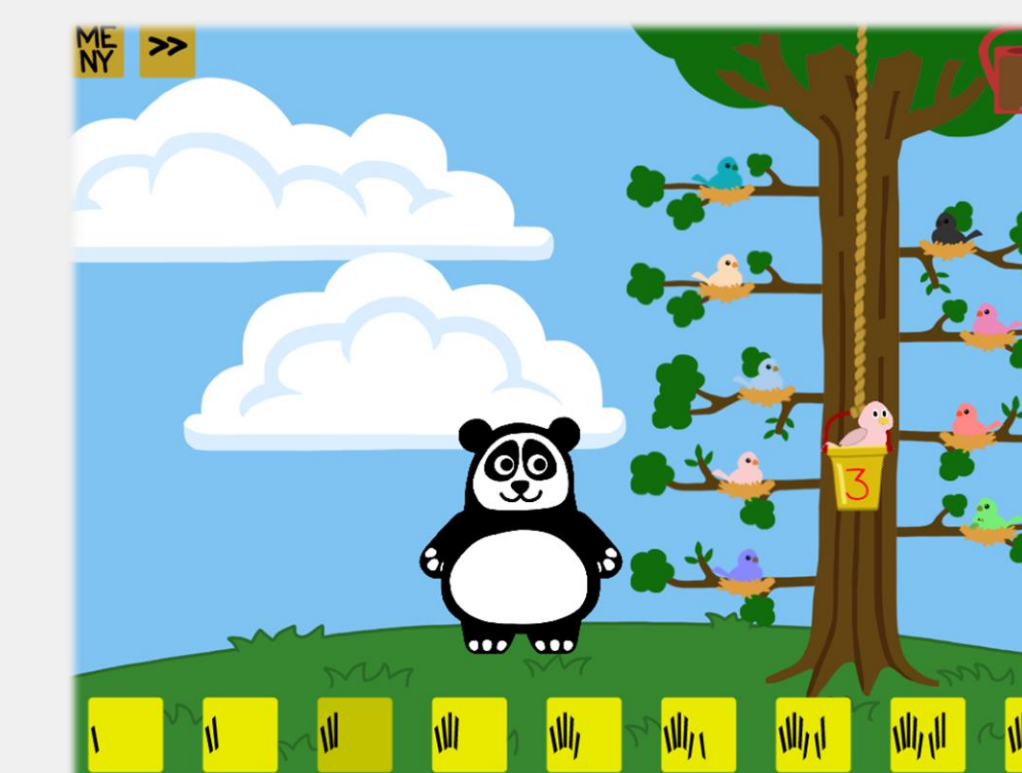
Unexpected event



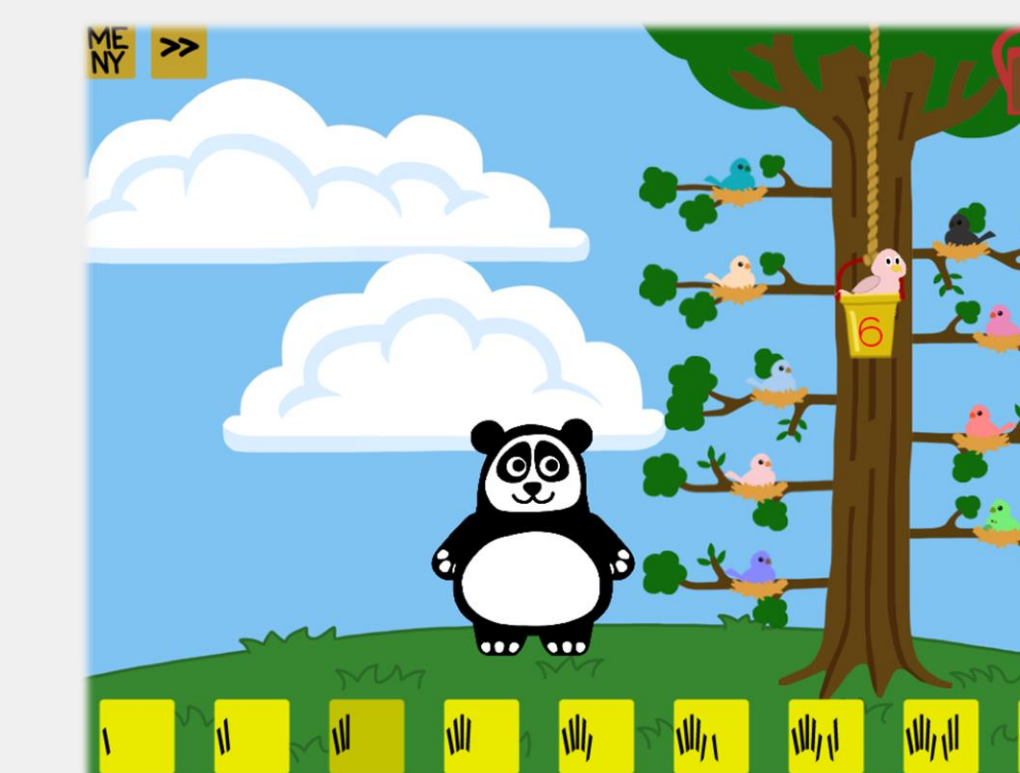
The player chooses an elevator button



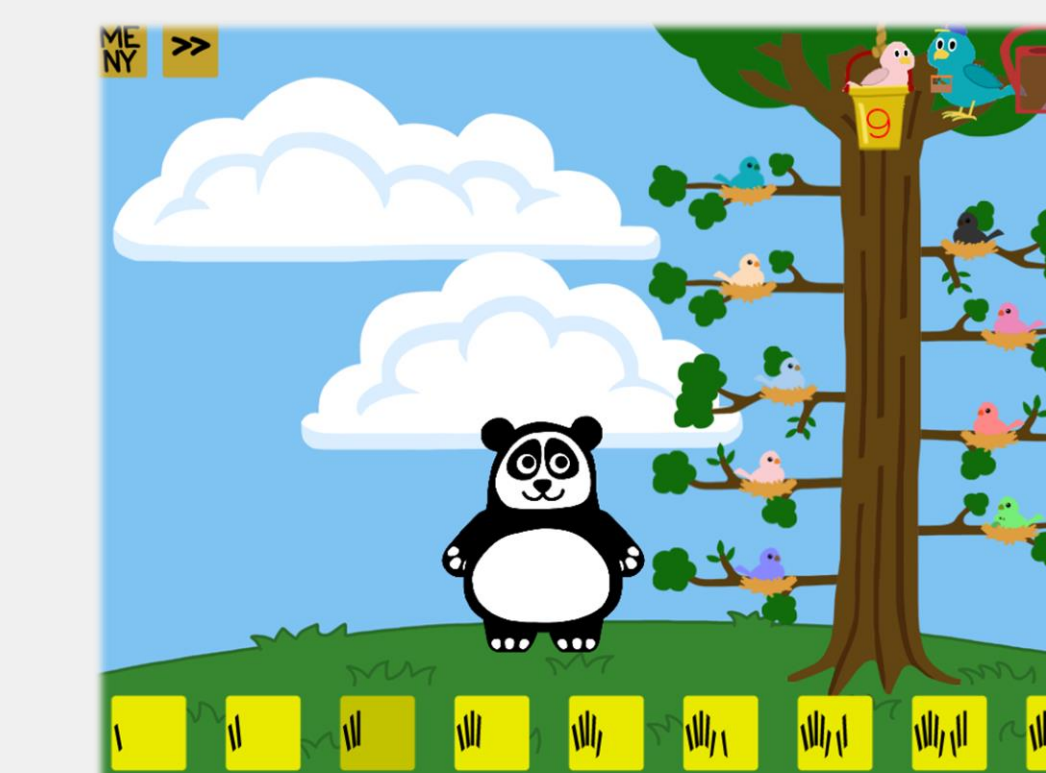
A baby bird jumps into the elevator



A baby bird at the correct branch



The elevator continues past the correct branch

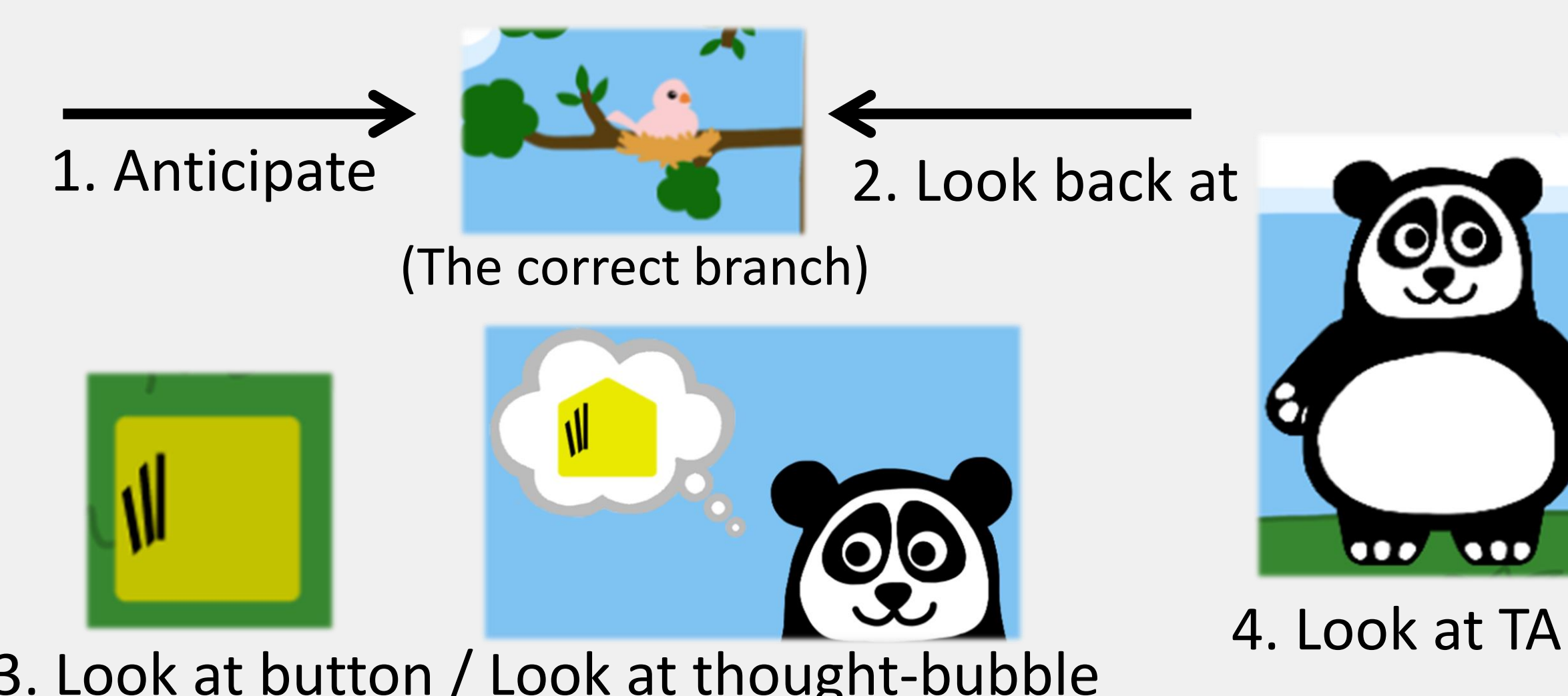


The elevator gets stuck in the tree top.

Eye-Tracking at preschools



Eye movements of interests



Performance

$$P = \frac{C}{T}$$

P = Performance
 C = Total number of correct answers from trials of the eye-tracking experiment.
 T = Total number of tries (correct answers + wrong answers) from the trials of the eye-tracking experiment.