Are game elements fueling learners' motivation via positive affect?




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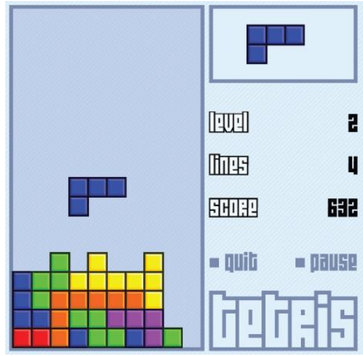
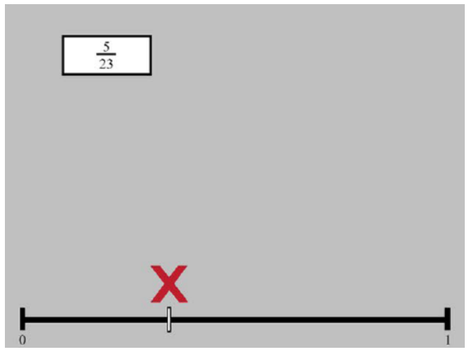
Background



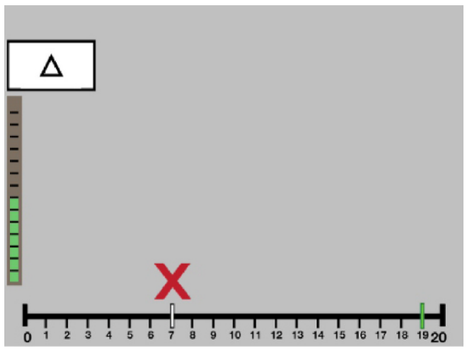
- Game elements can make a difference for learning… (Mayer, 2020; URL: https://lccn.loc.gov/2019009508)
- …but sometimes apparently not…
- …and sometimes it seems just not that simple

Fraction estimation: No difference in accuracy



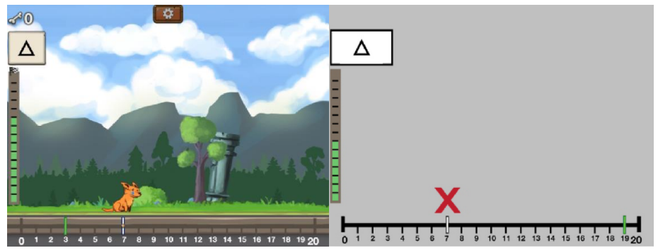
(Ninaus et al., 2023; doi:10.1007/s11423-023-10263-8)

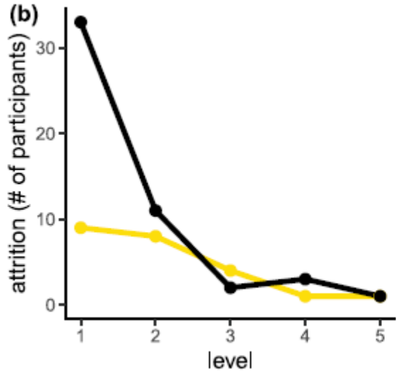
Associative learning: Differences in engagement, affect, motivation, but not overall recall

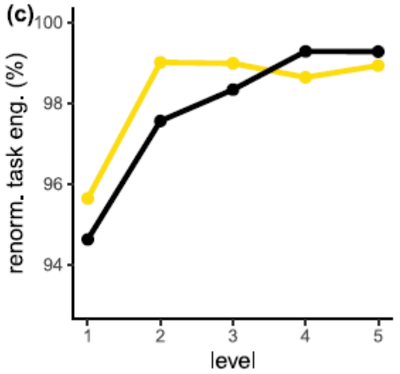


(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)

Background







- Game elements can influence **emotional engagement** and…

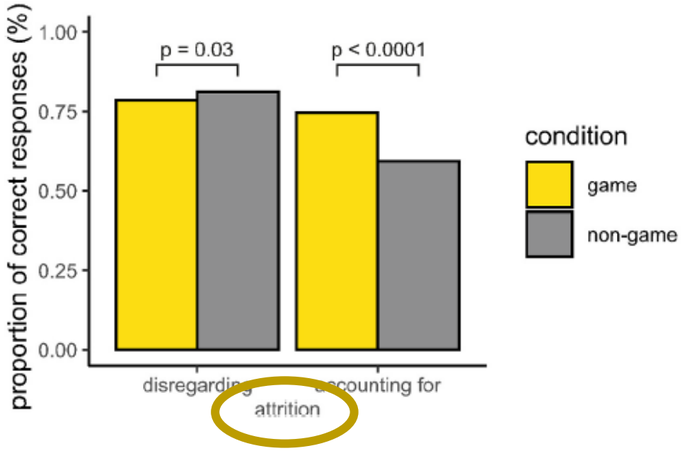
(Ninaus et al., 2019 doi:10.1016/j.compedu.2019.103641; Greipl et al., 2021; doi:10.1145/3474667)

- …**behavioral engagement & disengagement**…

(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)

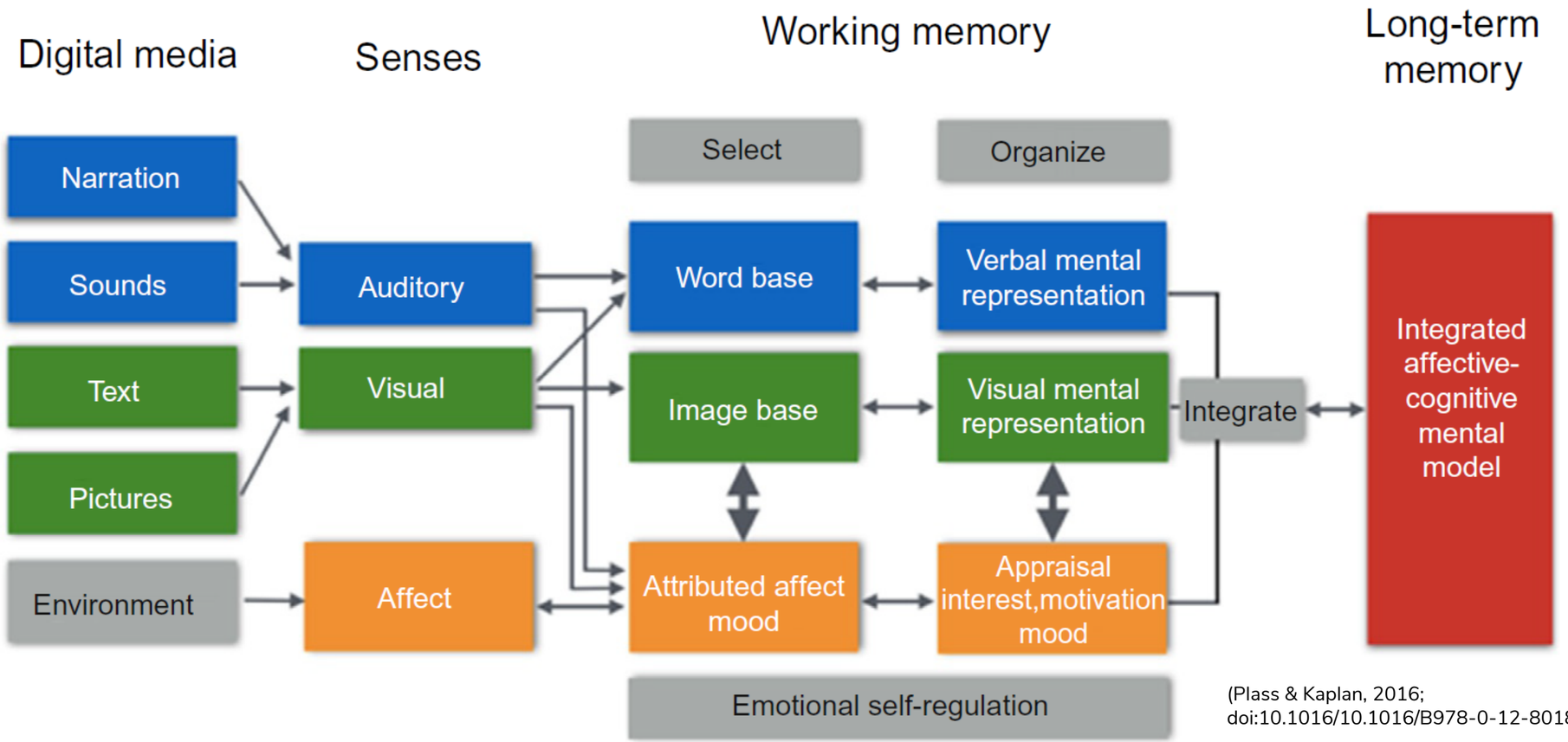
- …which can make an important **difference for cognitive outcomes**.

- How do game elements “**make the distinction that makes the difference**”?



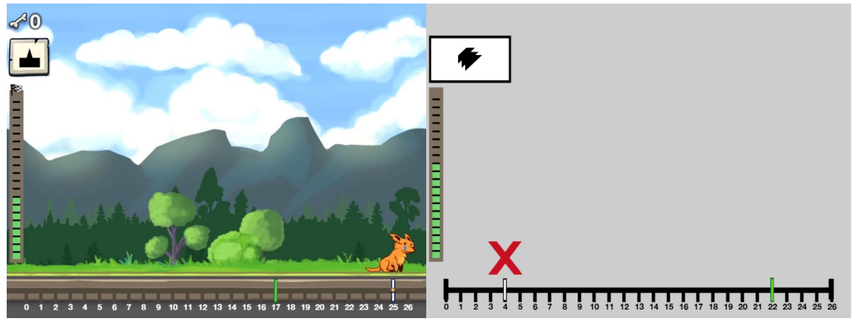
Background

- Integrated cognitive affective model of learning with multimedia (ICALM):

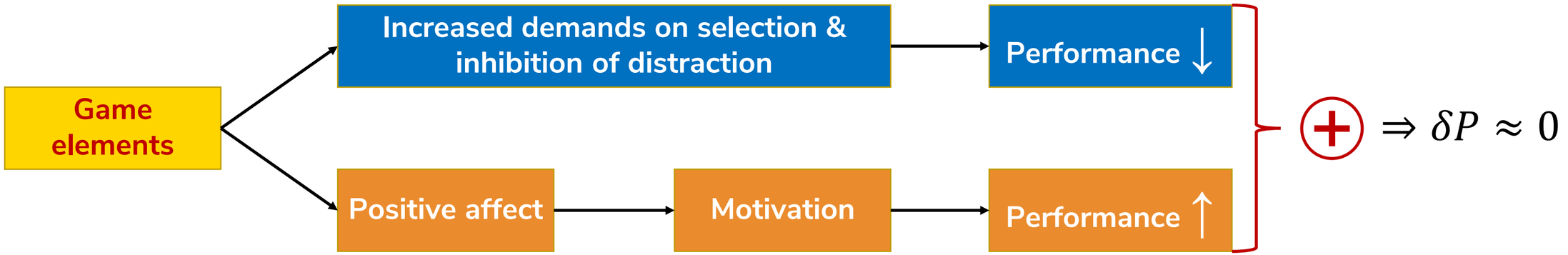


(Plass & Kaplan, 2016; doi:10.1016/10.1016/B978-0-12-801856-9.00007-4)

Research question



- Is our current experimental paradigm in line with this simple conceptual framework?



- Could this scheme be a viable explanation for our previous results?

(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)

Specific hypotheses

1. Cognitive learning outcomes are very similar between task conditions.

2. Task versions differ regarding affective and motivational outcomes.

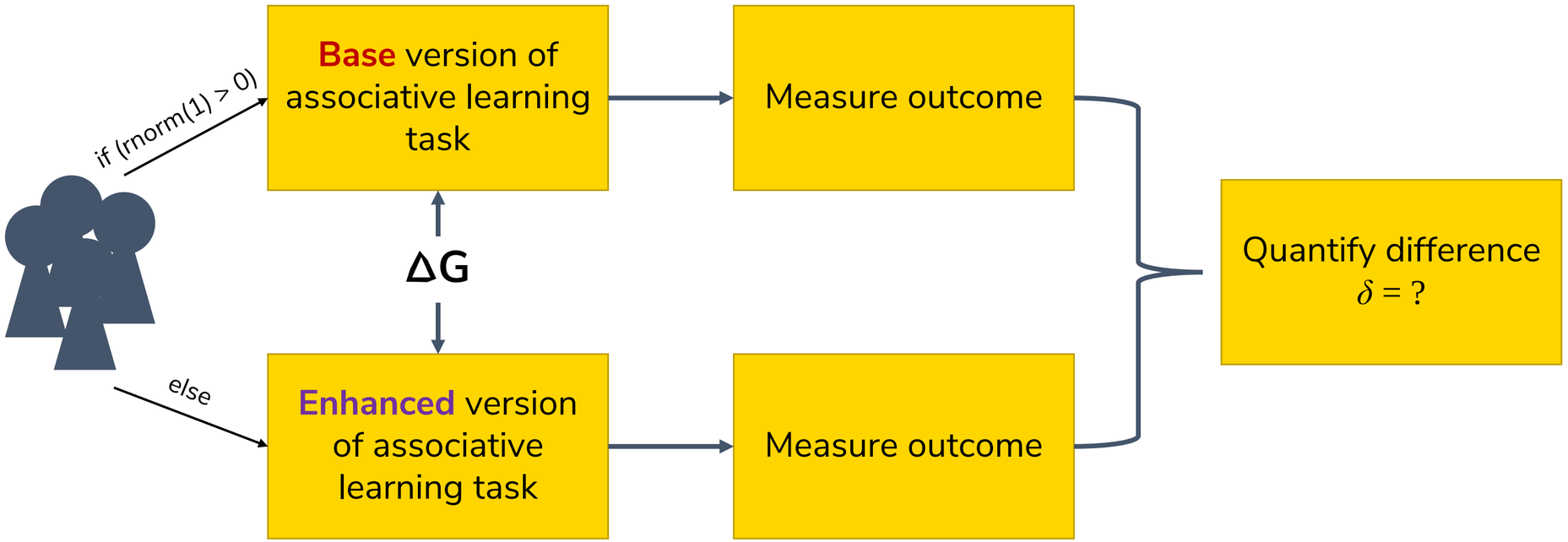
3. The effect of game elements on cognitive outcomes is partially mediated by motivational differences.

4. The effect of game elements on motivational outcomes is partially mediated by affective differences.

Experimental setup

- Typical value-added experiment

(Mayer, 2020; URL: https://lccn.loc.gov/2019009508)

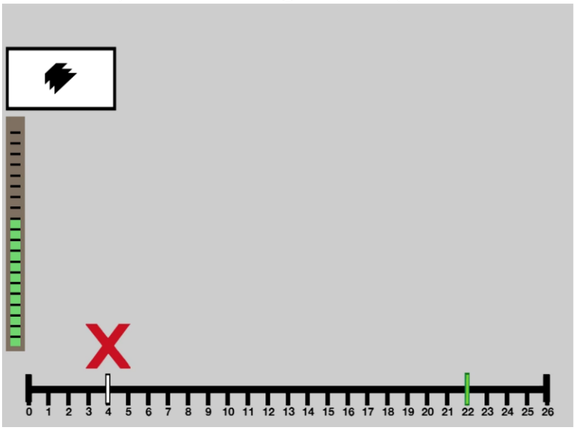


Learning task

- **Associative learning task**:
  - Unknown associations between symbols and numbered positions on number line
  - In each trial a symbol is presented and arrow keys + space bar are used to select position on number line
  - Corrective feedback after each trial
  - 20 symbols per level
  - 5 consecutive levels
  - Goal: Learn as many associations as possible over 5 levels
- **Game elements (ΔG)**:
  - Visual aesthetics
  - Narrative
  - Scoring system

Based on the NumberTrace engine (https://www.youtube.com/watch?v=T7s7xSlLrac)

Base (or „non-game“) version:

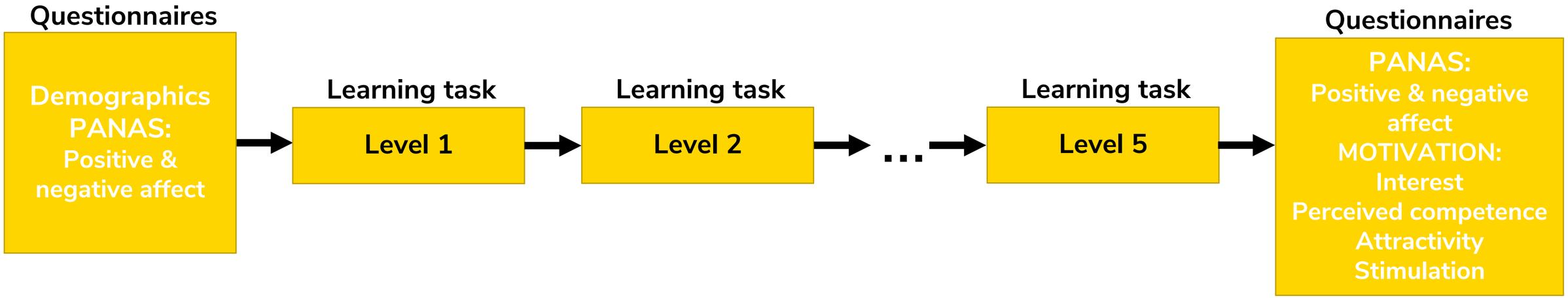


Enhanced (or „game“) version:

ΔG

Participants & study design

- n = 61; 44 female, 15 male, 2 diverse; 18-64 years (*Mdn* = 24, *MAD* = 4.45 years); mostly students
- Online study with compensation (course credit)
- Cognitive outcomes: efficacy ($N_{corr}(5)$), efficiency (rate constant c in $N_{corr}(L) = N_{max}\left[1 - e^{-c(L-1)}\right]$)

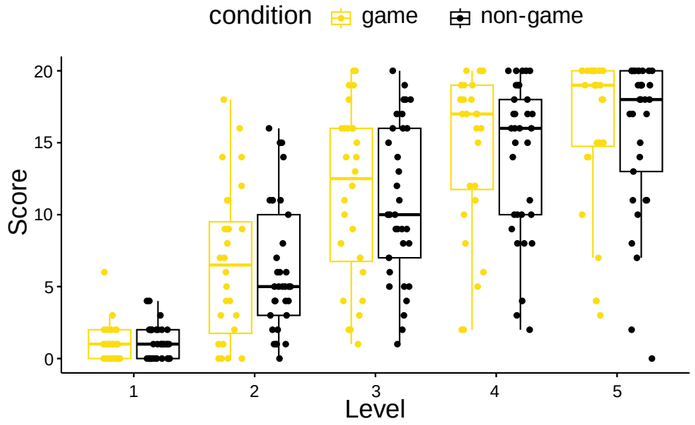


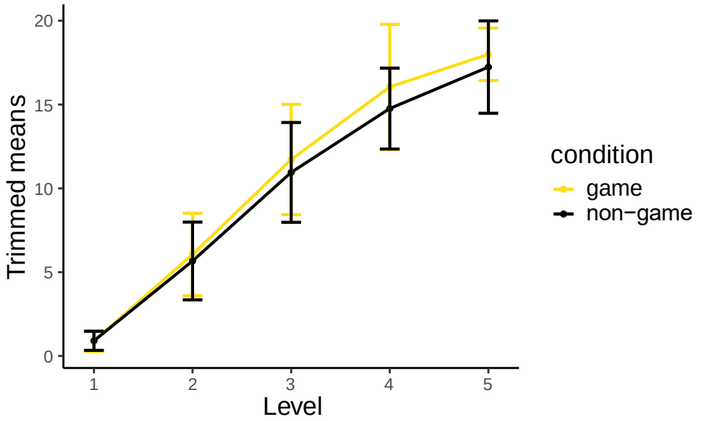
PANAS: 20 adjectives given (e.g., excited or distressed). Rating of intensity from 1 (not at all) to 5 (very much). (Breyer & Bluemke, 2016)
Interest – Example: „The activity in the learning task was fun.“ || 1 (Not at all) to 5 (Completely).
Perceived competence – Example: „I am satisfied with my performance.” || 1 (Not at all) to 5 (Completely). (KIM: Wilde et al., 2009)
Attractivity: How enjoyable, good, pleasing, pleasant, attractive, friendly was the task? On a scale 1-7.
Stimulation: How valuable, exciting, interesting, motivating was the task? On a scale 1-7. (UEQ: Schrepp et al., 2017)

Results: Cognitive outcomes

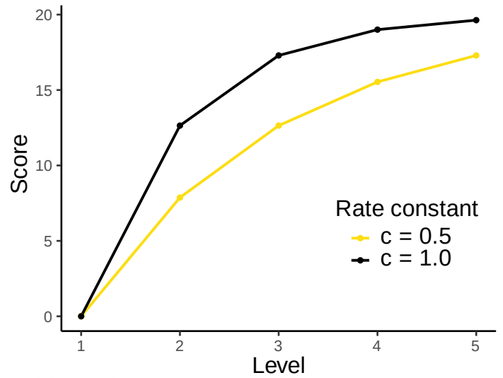
Hypothesis 1: Cognitive learning outcomes are very similar between task conditions.

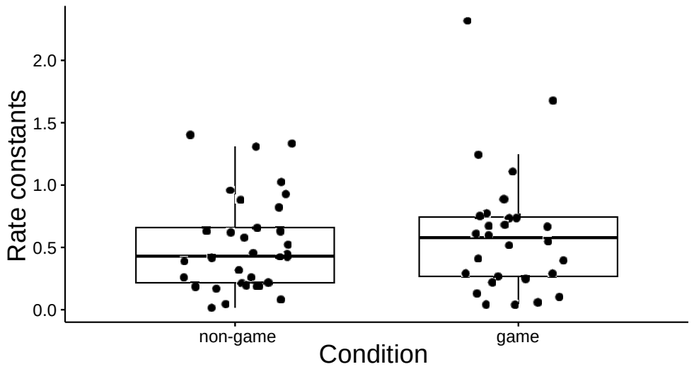
- Learning efficacy:
  not significantly different at level 5,
  $Y_t = 0.57$, $p = 0.452$, $\delta_t = 0.15$.





- Learning efficiency:
  Rate constant c in $N_{corr}(L) = N_{max}\left[1 - e^{-c(L-1)}\right]$
  not significantly different,
  $Y_t = 0.48$, $p = 0.479$, $\delta_t = 0.18$.

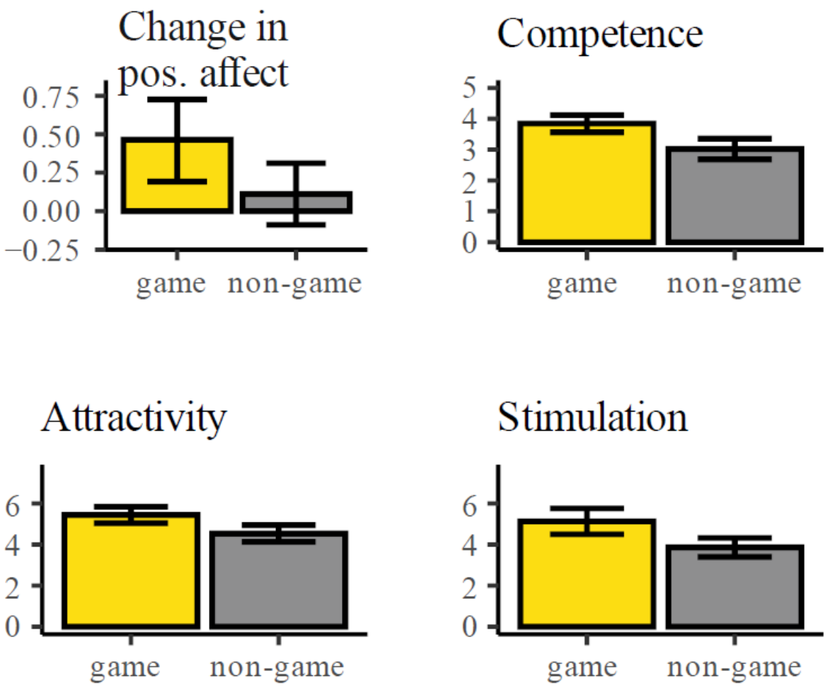




Results: Affective and motivational outcomes

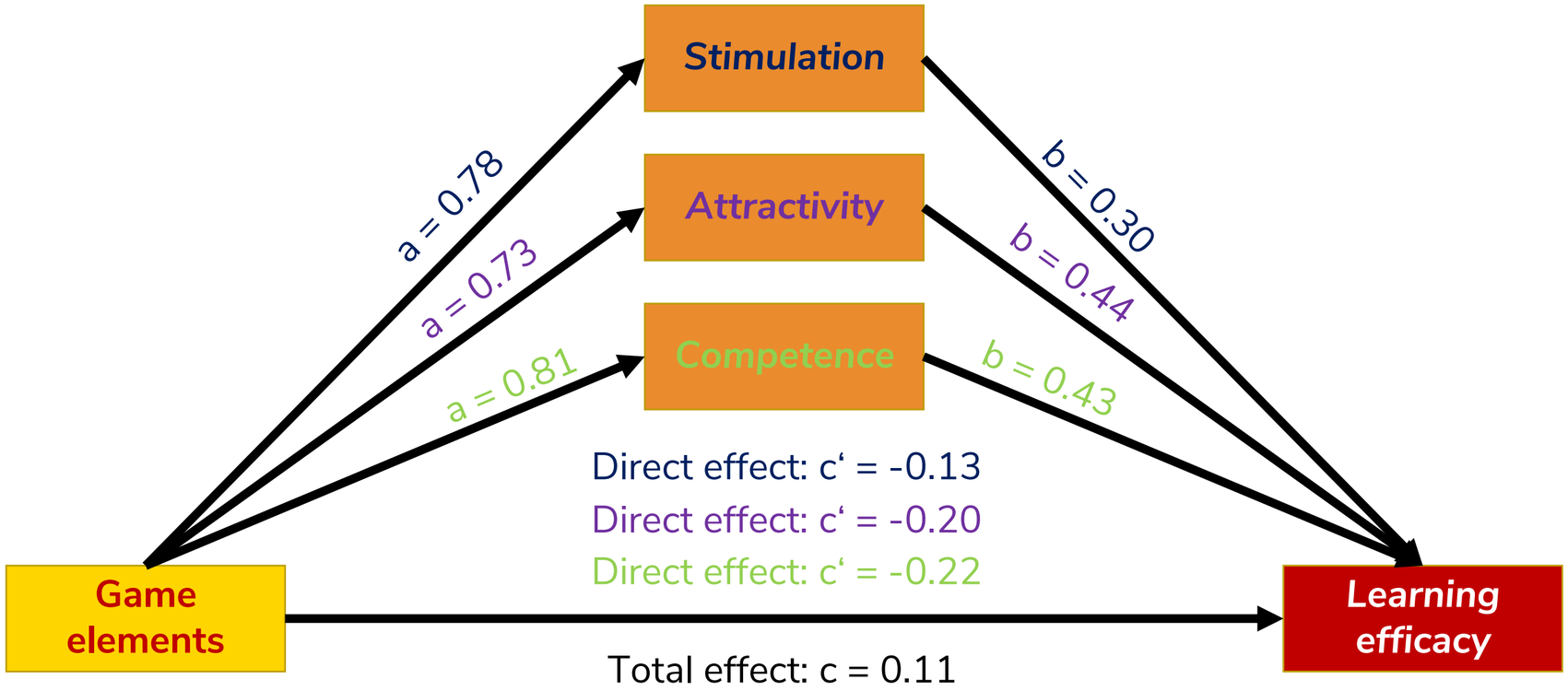
Hypothesis 2: Task versions differ regarding affective and motivational outcomes.

- No significant differences in
  - *Pre-post change of negative affect*:
    $Y_t = 1.67$, $p = 0.090$, $\delta_t = 0.48$
  - *Interest* (subscale of intrinsic motivation questionnaire):
    $Y_t = 0.56$, $p = 0.538$, $\delta_t = 0.16$
- Significant differences in
  - *Pre-post change of* ***positive affect***:
    t(53.78) = 2.01, p = 0.049, *d* = 0.52
  - **Competence** (subscale of intrinsic motivation questionnaire):
    t(58.42) = 3.52, p < 0.001, *d* = 0.89
  - ***Attractivity*** (subscale of UEQ):
    $Y_t = 3.00$, $p = 0.003$, $\delta_t = 0.82$
  - ***Stimulation*** (subscale of UEQ):
    $Y_t = 3.17$, $p < 0.001$, $\delta_t = 0.87$



Results: Mediation 1

Hypothesis 3: Effect of game elements on cognitive outcomes is partially mediated by motivational differences.



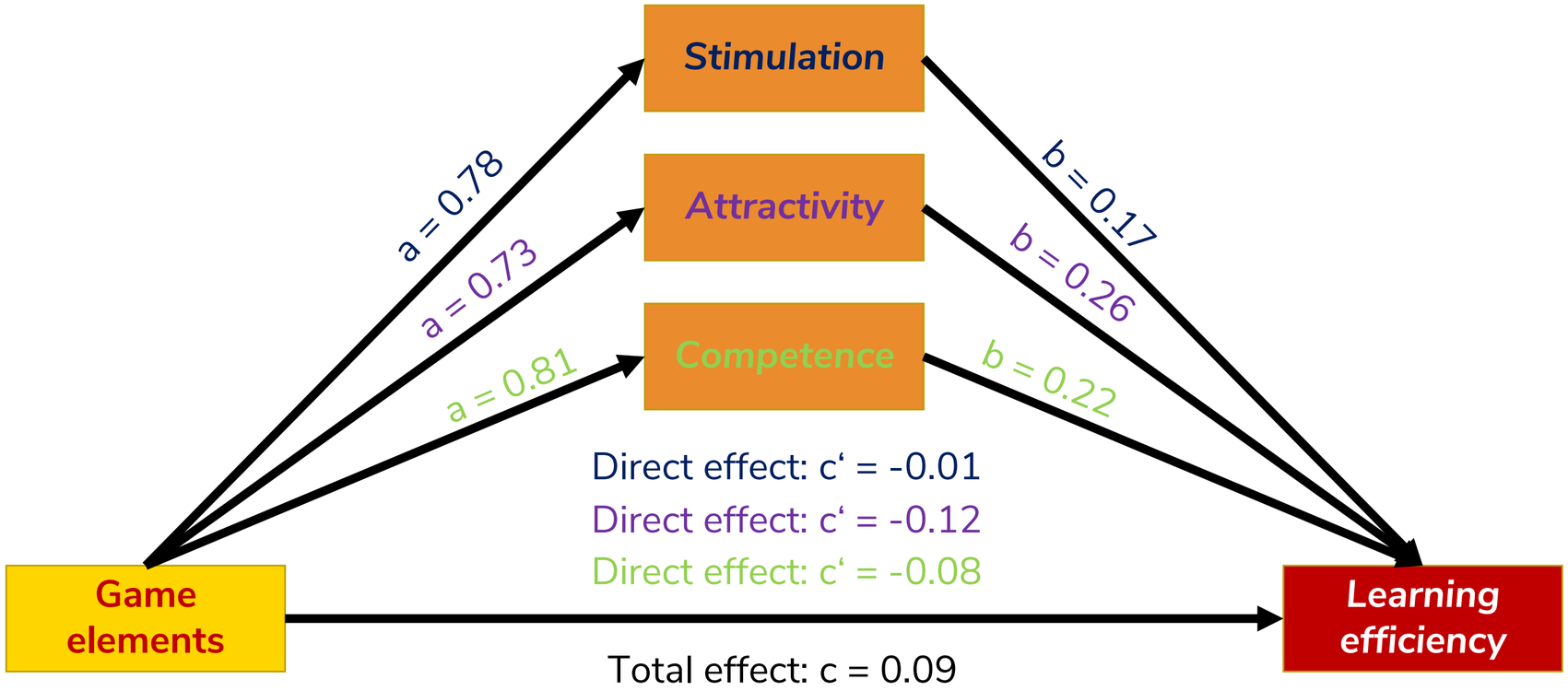
Indirect effect: ab = 0.26 [0.05, 0.60]*

Indirect effect: ab = 0.45 [0.15, 0.85]*

Indirect effect: ab = 0.39 [0.12, 0.73]*

Results: Mediation 1

Hypothesis 3: Effect of game elements on cognitive outcomes is partially mediated by motivational differences.



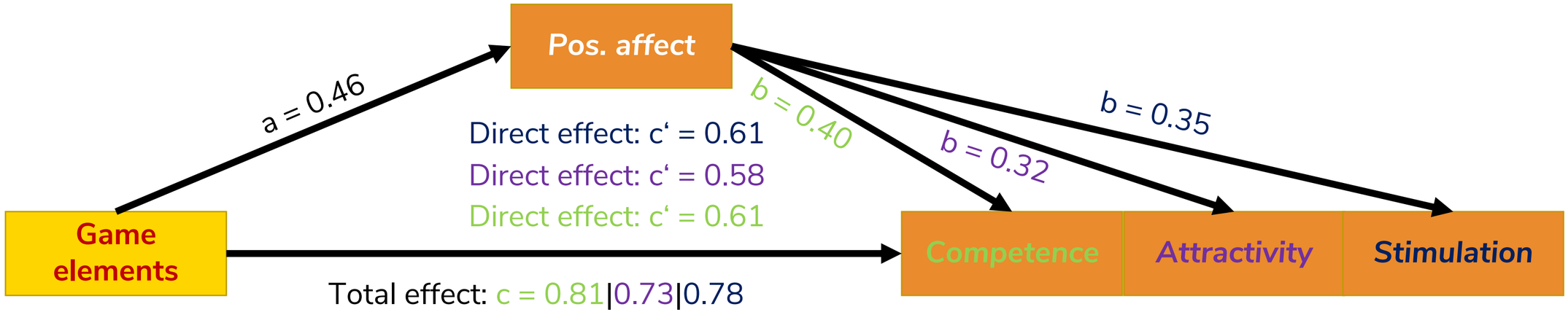
Indirect effect: ab = 0.12 [-0.03, 0.37]

Indirect effect: ab = 0.24 [0.03, 0.55]*

Indirect effect: ab = 0.18 [-0.01, 0.47]

Results: Mediation 2

Hypothesis 4: Effect of game elements on motivational outcomes is partially mediated by affective differences.



Indirect effect: ab = 0.18 [0.01, 0.44]*

Indirect effect: ab = 0.17 [0.01, 0.42]*

Indirect effect: ab = 0.21 [0.01, 0.48]*

Discussion: Specific hypotheses

1. Cognitive learning outcomes are very similar between task conditions. ✓
2. Task versions differ regarding affective and motivational outcomes. ✓
3. Effect of game elements on cognitive outcomes is partially mediated by motivational differences. ✓~
4. Effect of game elements on motivational outcomes is partially mediated by affective differences. ✓

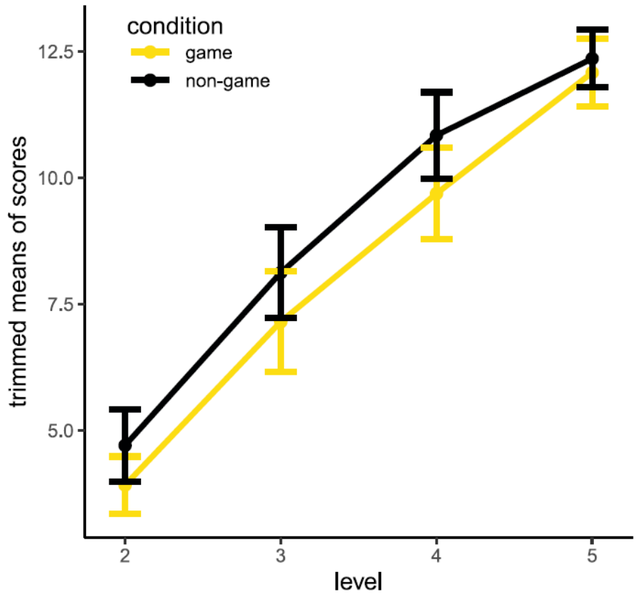
So are game elements fueling learners' motivation via positive affect?

Momentary conclusion: In case of our task… And our experimental setup… And our contextual and all other constraints and assumptions… Partially, maybe…

Discussion: Other findings

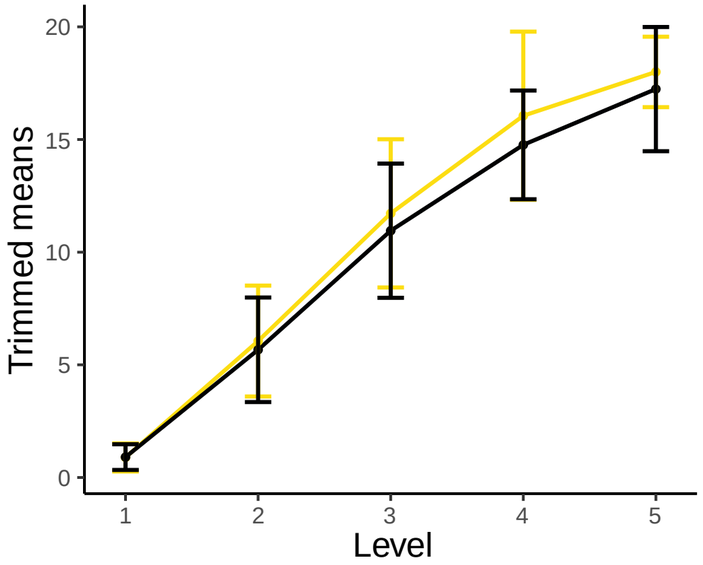
- Previously:

(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)



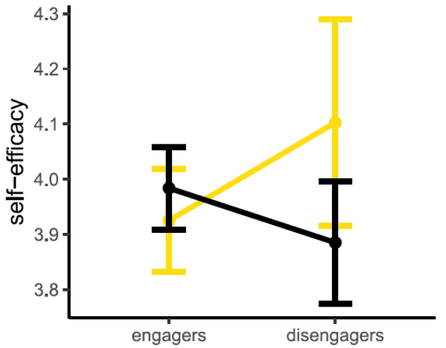
Online & almost no compensation

- Now:



Online for course credit

(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)

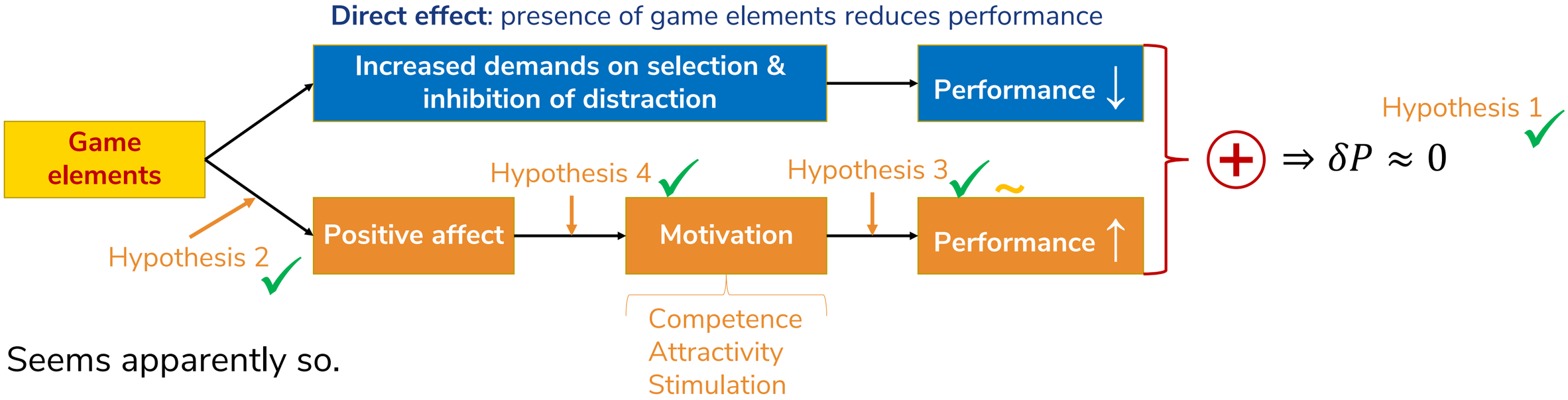


→ It seems as if indeed those who would need it the most are most likely to drop out in the non-game condition

Discussion: There and Back Again

- Could this scheme be a viable explanation for our previous results?

(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)



- Seems apparently so.

Discussion

- What are the mechanisms? How do game elements induce PA/motivation?
- Earlier speculation: attractivity of game elements

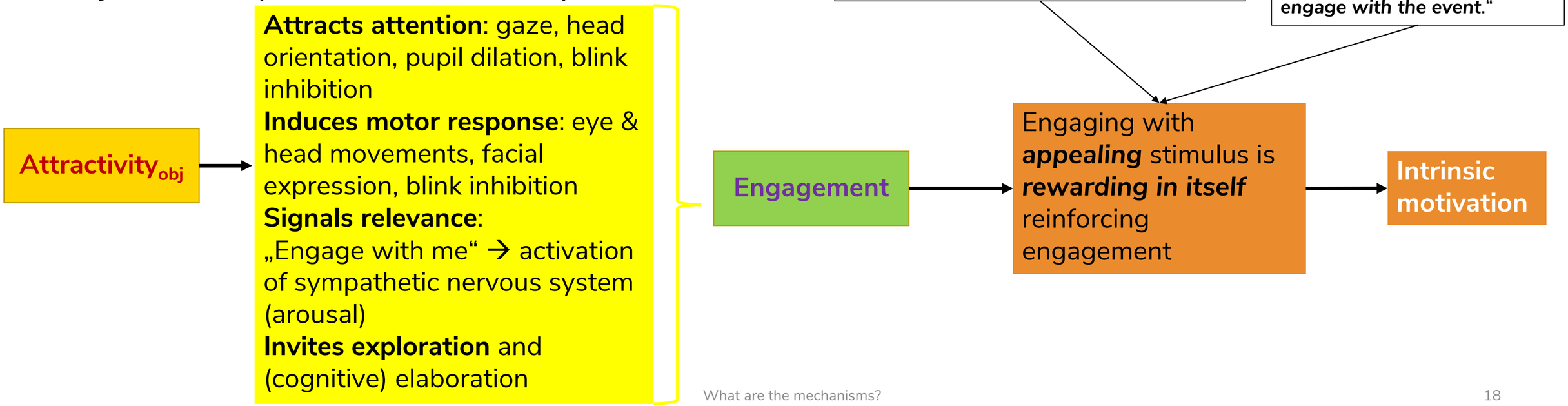
(Huber et al., 2023; doi:10.1016/j.chb.2023.107948)

- Objective vs. perceived attractivity

(Sander et al., 2023; doi:10.1515/REVNEURO.2003.14.4.303)

„An event is relevant for an organism if it can significantly influence (positively or negatively) the attainment of his or her goals, the satisfaction of his or her needs, ***the maintenance of his or her own well-being***, and the well-being of his or her species.“

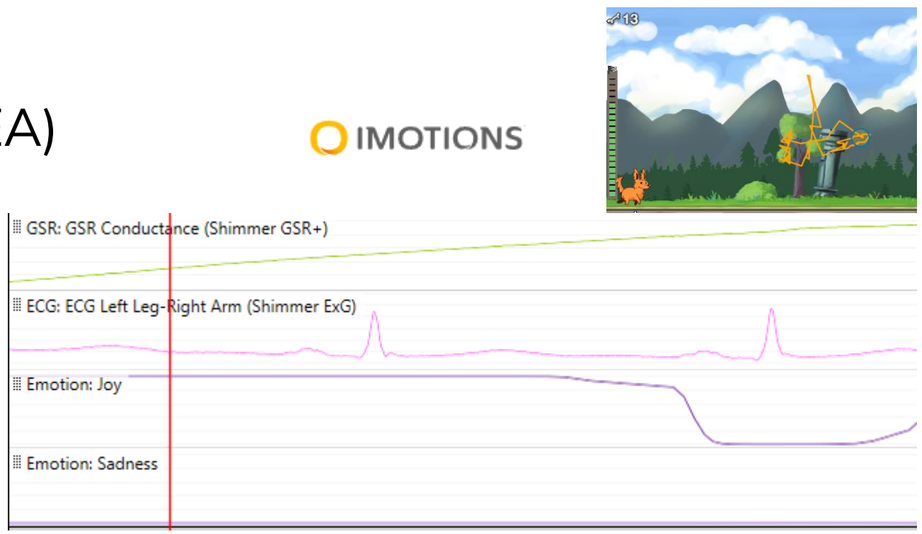
„Positive stimuli, such as happy faces, amusement-inducing and erotic pictures or movies, can also be ***relevant because of their intrinsic pleasantness inviting the organism to engage with the event***.“

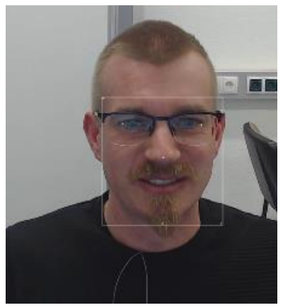


Outlook

- Gaze, head orientation, pupil dilation, blink inhibition, eye & head movements, facial expressions, arousal → all this is actually measurable

- Laboratory study employing the same experimental paradigm but also assessing
  - Electrodermal activity (EDA)
  - Electrocardiography (ECG)
  - Facial expression analysis (FEA)
  - Eye-tracking





Outlook

1 week later:
Delayed recall
Personality questionnaires

ASKU
PANAS
EES
SAM
SE

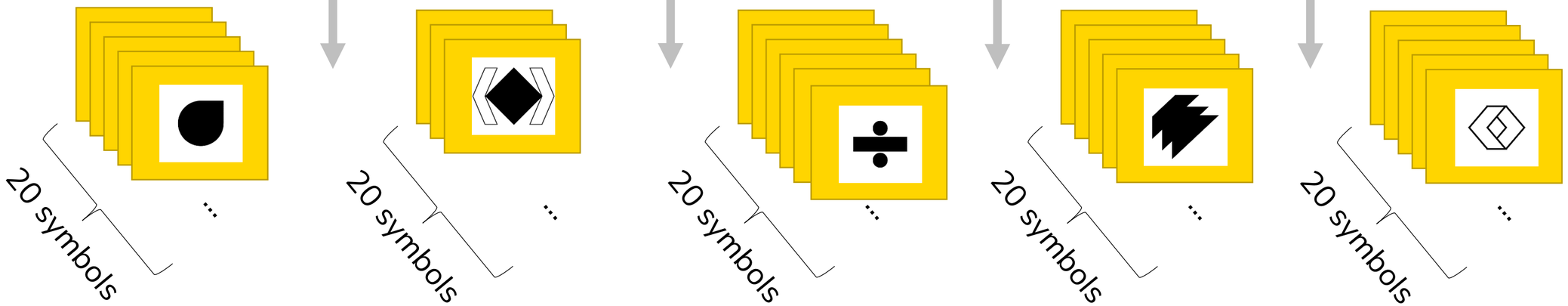
EES
SAM
SI&SE

EES
SAM
SI&SE

EES
SAM
SI&SE

EES
SAM
SI&SE

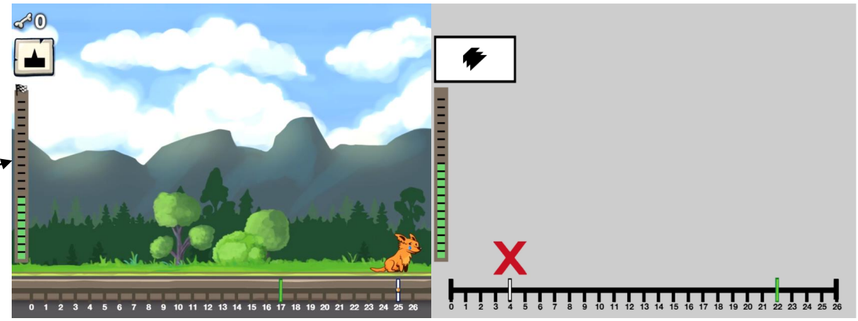
Other Quest.
EES
SAM
SI
Imm. Recall



Psychophysiological assessment

Outlook

You might see this more often



- Many **more planned studies** to go beyond the limitations of the just presented one:
  - Clarify **mediation** results for **learning efficiency** (replication studies)
  - Clarify relation between **self-efficacy, game elements, and attrition** (large-scale online replication study)
  - How do results depend on **comfort/familiarity with (serious) games**?
  - How do they depend on **prior knowledge** or existing expertise with memorization tasks?
  - How do they depend on the **value** assigned to the **task** by the participants?
  - What does the **difference in perceived competence** mean? Overreliance in the case of game elements or misjudgment in the case of less gameful condition?
  - How do **individual game elements** contribute? (Finer & further resolution of the **gamefulness dimension**)

Conclusions

- We conducted
  - a value-added, online experiment
  - to test the hypothesis of antagonistic effects of game elements on cognitive learning outcomes
  - and their mediation via positive affect and motivation.
- Our results indeed suggest
  - that the additional cognitive demands introduced by game elements
  - are effectively balanced by their indirect effects along the affect-motivation-cognition pathway
  - in agreement with the ICALM model.
- We outlined further studies based on our experimental paradigm to shed further light on the mechanisms by which game elements can influence learning.

Questions?

- Contact: stefan.huber@uni-graz.at