GAZE-CONTROLLED GAMING

Immersive and Difficult but not Cognitively Overloading

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GAZE-CONTROLLED GAMING

- Interest in gaze-controlled gaming is **resurging** with recent developments of eye tracking technology
- According to Bednarik et al. (2009), gaze-gaming players:
  - outperform others on problem-solving measures
  - commit fewer errors
  - are more immersed
  - benefit from a better user experience

GAZE-CONTROLLED GAMING

- Target acquisition and target tracking in games:
    - is similar with gaze input as it is with the mouse
    - is similar with gaze input as with touch screen
    - has considerable potential

(San Agustin et al., 2009)

GAZE-CONTROLLED GAMING

- But…
  - subjective users' attitudes toward eye-controlled gaming over other devices are mixed
  - gaze-controlled games are more entertaining and engaging but more difficult (Nielsen et al., 2012)

GAZE-CONTROLLED GAMING

- Midas touch problem—every gaze movement triggers (Jacob, 1990)
- Gaze-controlled gaming may impinge on cognitive processes related to the game itself, e.g., decision making
  - increased cognitive requirements over control of eye-movements
  - potential of cognitive overload
- BUT cueing as an effective method of directing attention (Pomarjanschi et al., 2012) and can reduce cognitive overload

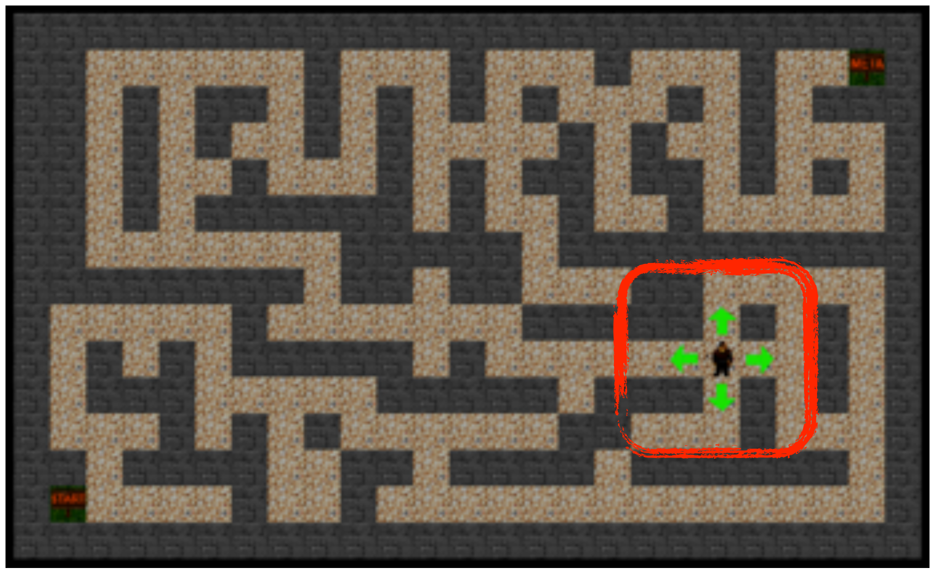
OUR APPROACH

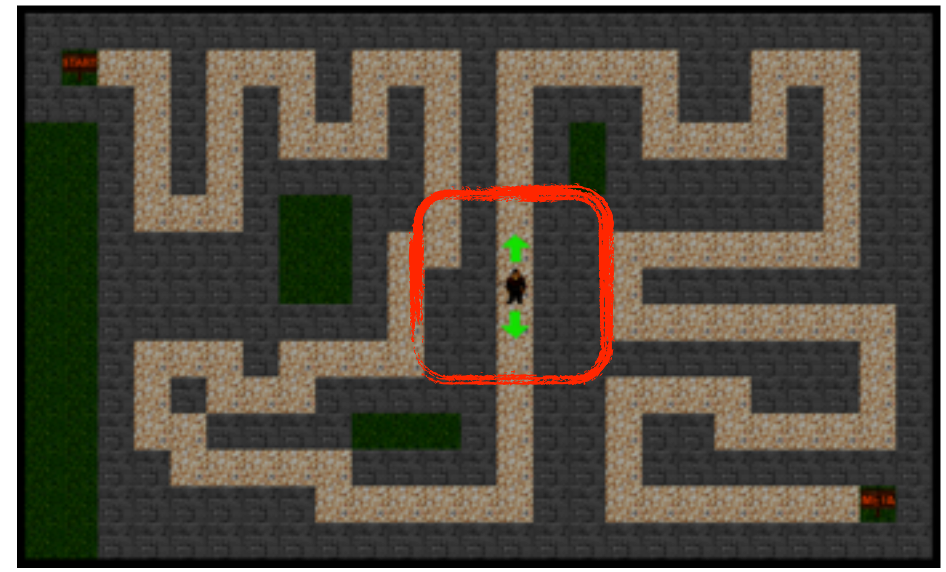
- The novelty of the present approach to gaze-controlled gaming is based on attentional cueing techniques used during gaming gaze control:
  - subtle gaze direction without the subtlety (McNamara et al., 2012)
  - cues are always visible (do not disappear upon detection of gaze direction)
- We hypothesize that **gaze-controlled gaming with overt cues:**
  - increases performance by lowering cognitive effort, and
  - increases the subjective gaming experience

OVERT CUES ON MAZE GAME

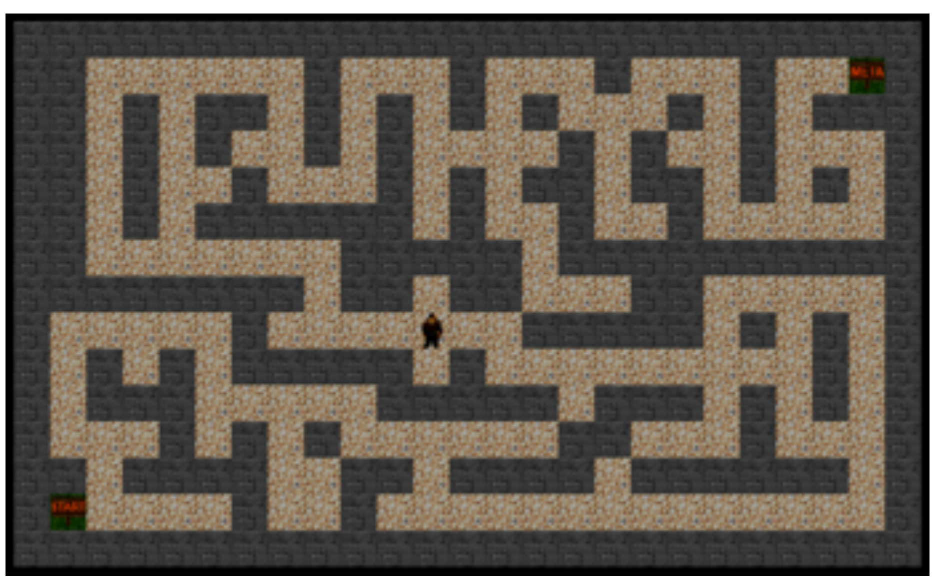
hard | easy

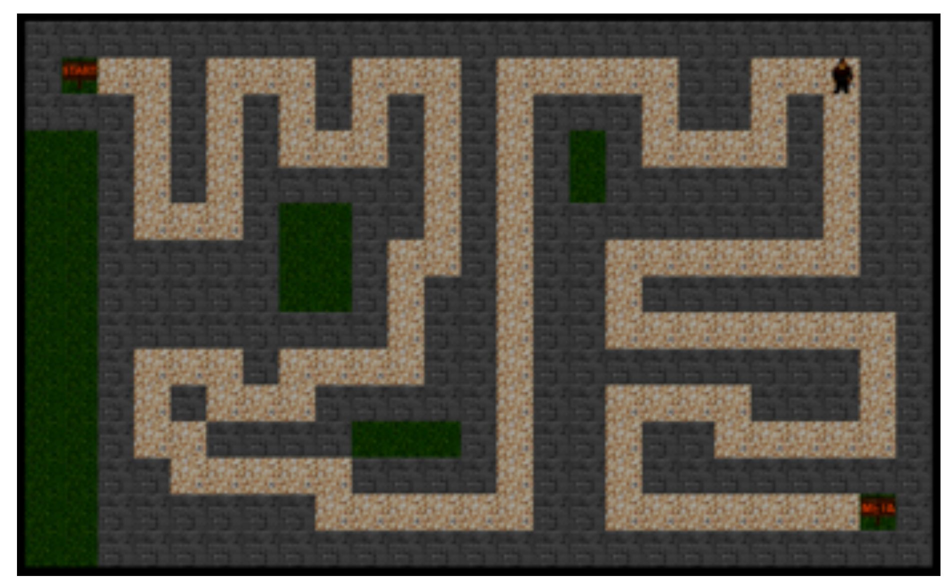
with cues





no cues





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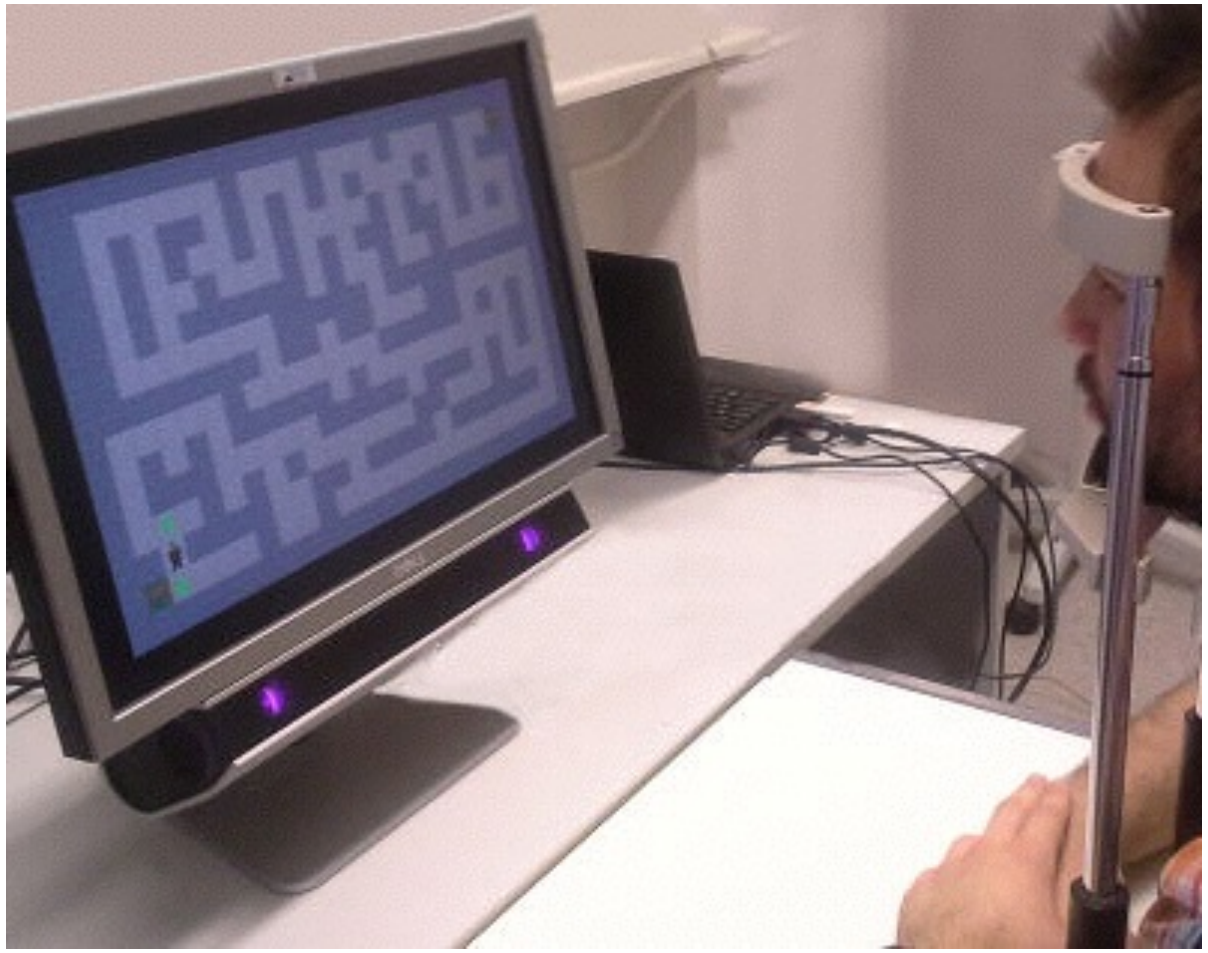
THE MAZE GAME

- The maze:
  - simple arcade game
  - goal to guide the character through the maze
  - consist of 25 columns and 15 rows of square tiles built in such a way that the maze started in one corner of the screen and ended in the opposite corner
- Written in Python and Pygame
- Floor tiles and player images taken from Daniel Cook (2006)

PARTICIPANTS & EXPERIMENTAL SETTINGS

- Sample:
  - N = 12 (6 male and 6 female, aged M = 30.5, SD = 4.06)
  - no previous experience with gaze-controlled games
- Eye movements were recorded at 120 Hz with an SMI RED 250 eye tracking system
- Participants were asked to keep their chin and forehead on a chin-rest



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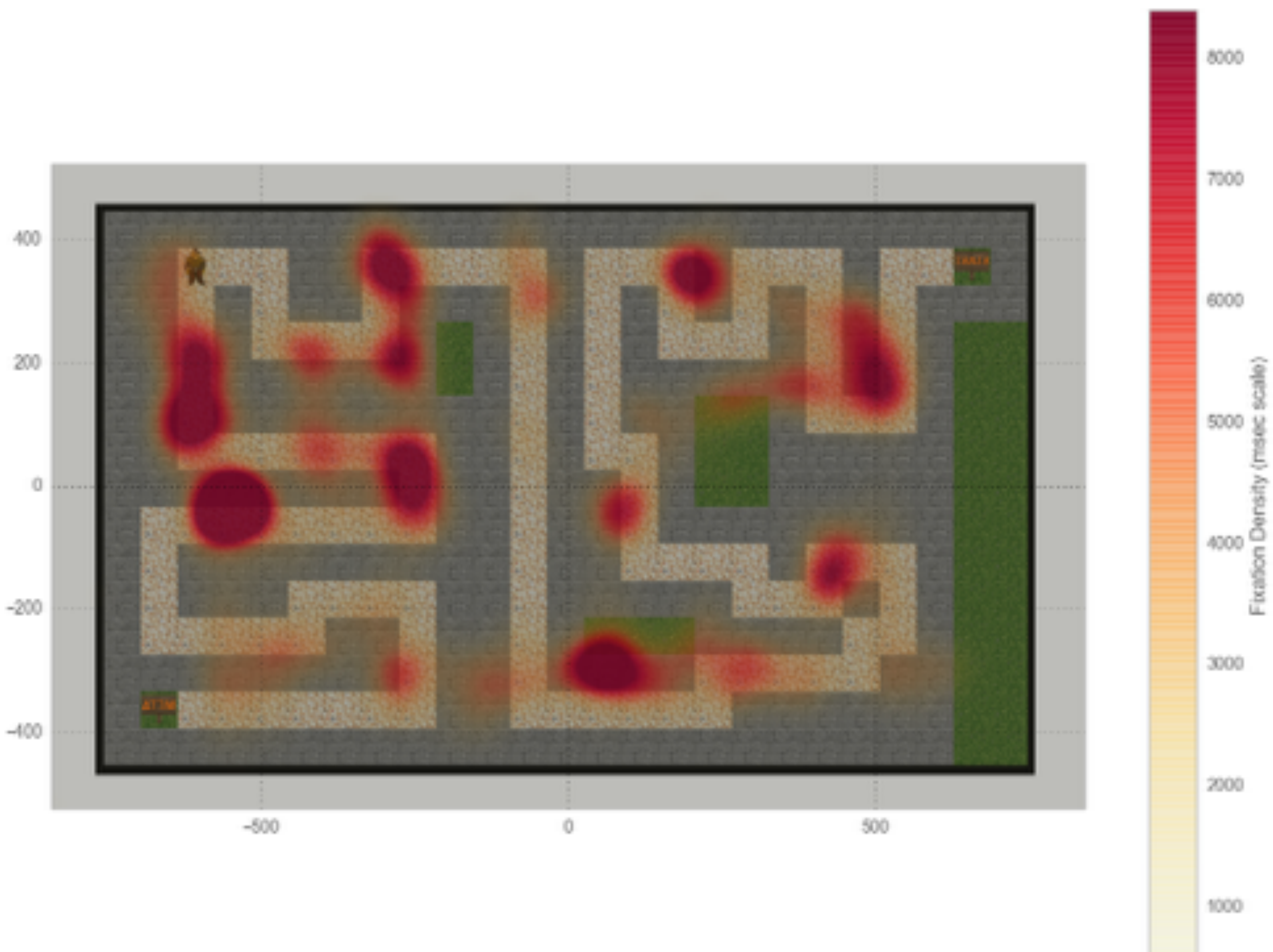
EXPERIMENTAL DESIGN

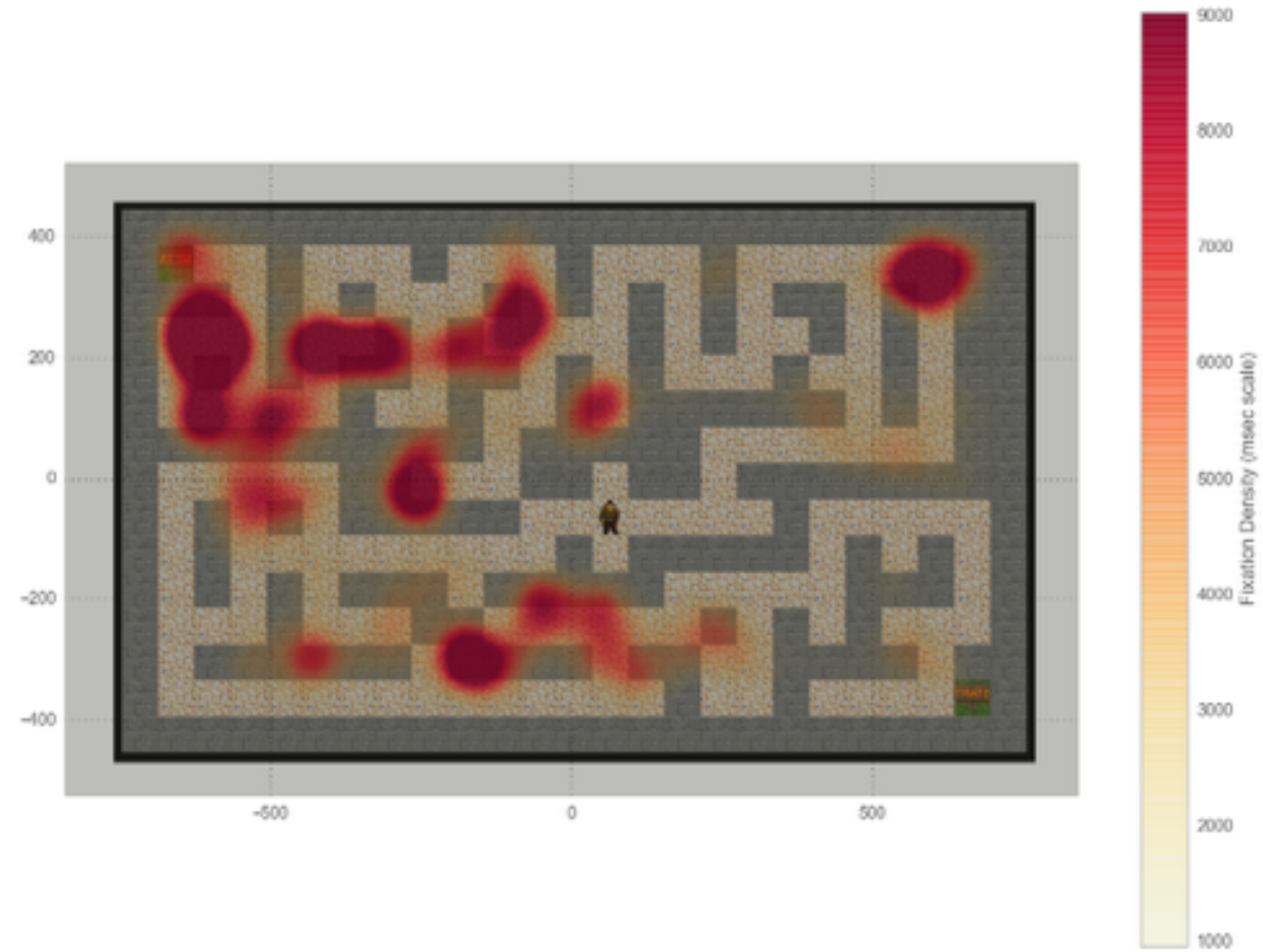
- Experimental design: 3 x 2
  - fully randomized within-subjects with two factors
  - game-control type
    1. gaze-controlled with cues
    2. gaze-controlled without cues
    3. keyboard-controlled
  - maze complexity
    1. easy
    2. hard

EXPERIMENTAL DESIGN

- Dependent measures and indicators:
  - performance (completion time, success rate)
  - cognitive load (pupil dilation, fixation duration, number of blinks)
  - visual attention distribution (percentage of gaze on path and the rest of the maze, number of saccades)
  - gaming experience (adopted Gaming Experience Questionnaire (Bednarik et al. 2009)

RESULTS





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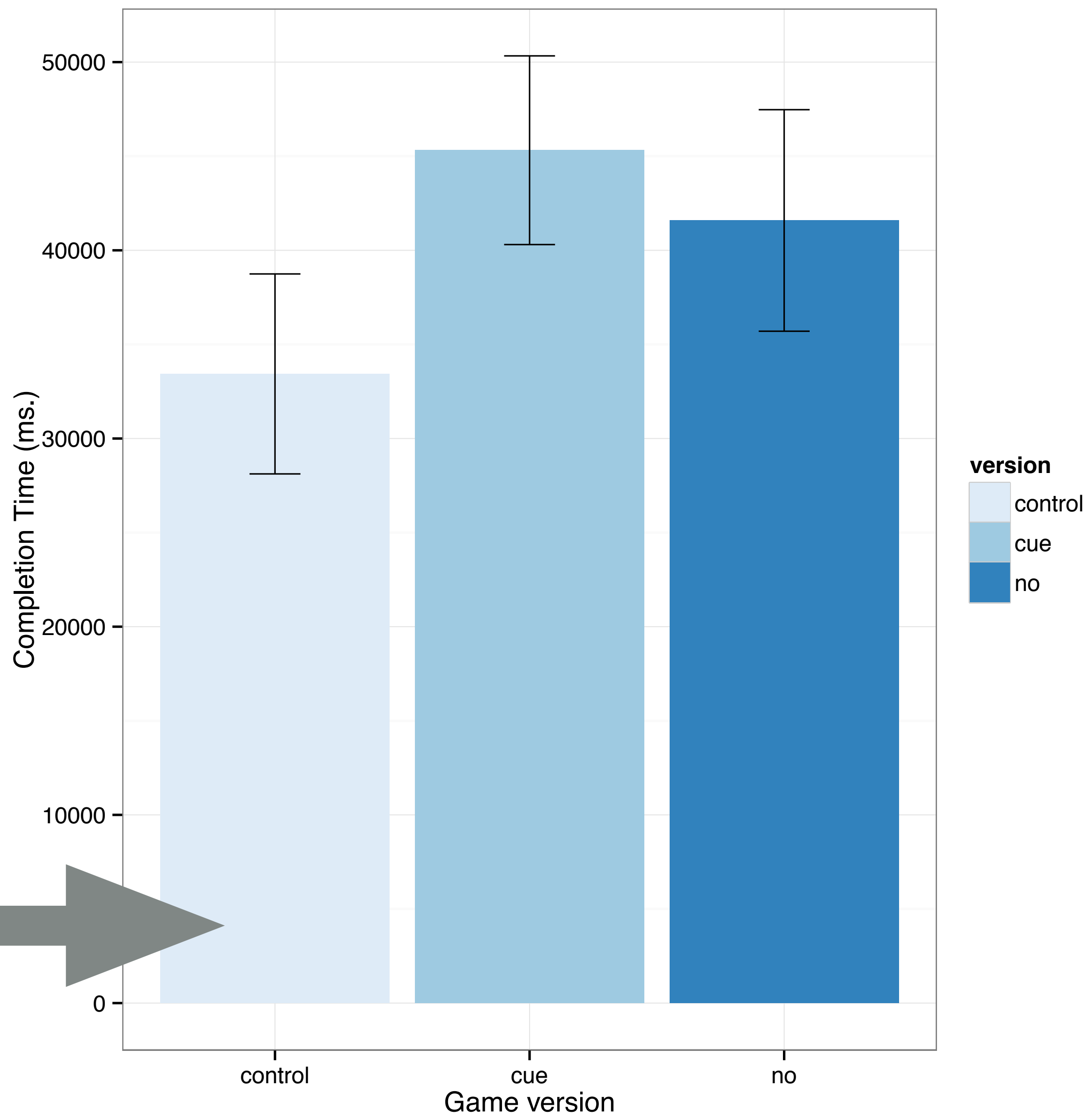
PERFORMANCE

- Game completion:
  - all participants completed the game
- Completion time:
  - faster when controlling the game with <u>keyboard</u>



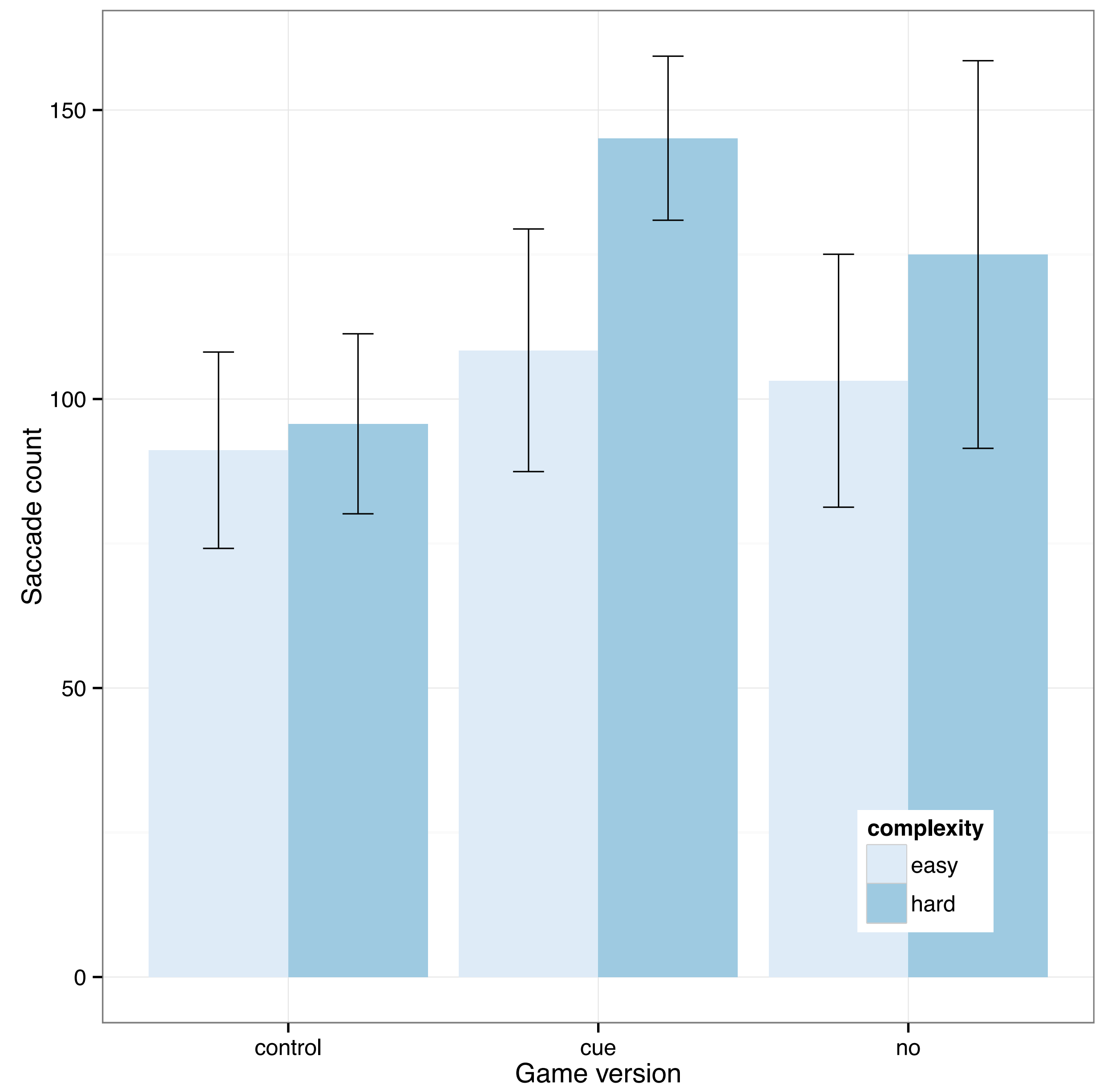
Analyses were computed with R statistical software using mainly linear mixed models (LMMs) fit with repeated data

COGNITIVE OVERLOAD

- Contrary to the hypothesis, there were no significant effects for
  - pupil dilation ($F(2,16) = 1.16, p > 0.1$)
  - average fixation time ($F(2,16) < 1$)
  - blink count ($F(2,16) = 1.11, p > 0.1$)

SACCADE COUNT

- Cued gaze-contingent game evoked significantly more saccades than the keyboard-controlled game
    - with greater time to completion, participants had more time to issue more eye saccades
- Participants exhibited more saccades with the complex maze



POSSIBLE EXPLANATIONS

- Conflicting hypotheses regarding gaze distribution:
  - gaze during cued gaze-controlled game play:
    - affords visual exploration to find optimal path (larger deviations from optimal path)

      or

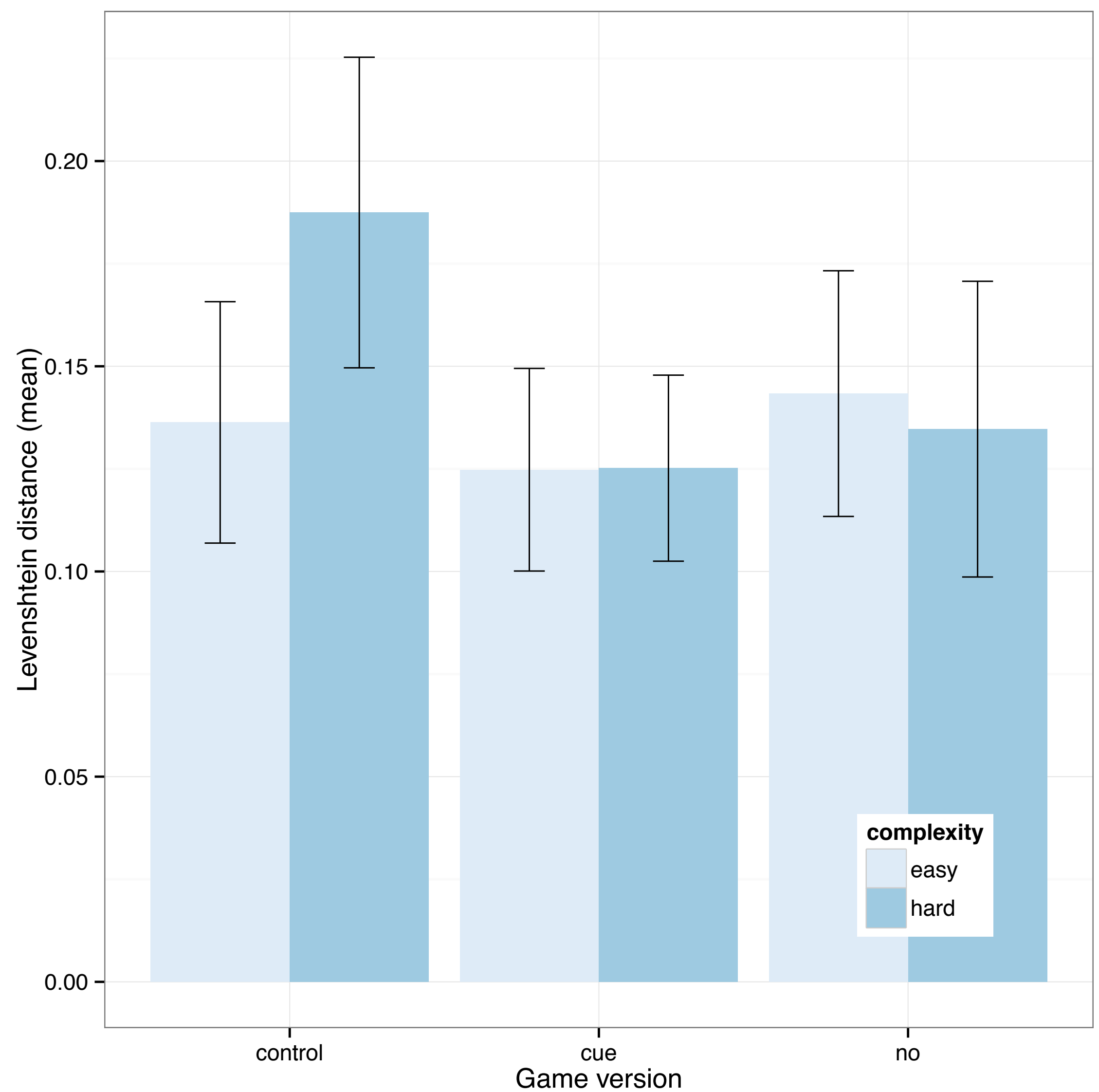
    - affords local saccades from game character to arrows (smaller deviations from optimal path)

POSSIBLE EXPLANATIONS

- Testing of the above:
  - each maze was divided into 6 x 4 AOI grids
  - the cumulative scanpath on such a grid was calculated for each participant
  - scanpaths were compared with the optimal path using the standardized Levenshtein distance (Levenshtein, 1965)

DISTANCE FROM OPTIMAL SCANPATH

- In all conditions participants spent about 60% of time gazing on paths (no differences between conditions)
- Main effect of game version:
    - smaller distance in cued gaze controlled than in control condition
- This result suggests cued gaze-contingent game elicits local saccades



GAME EXPERIENCE EVALUATION

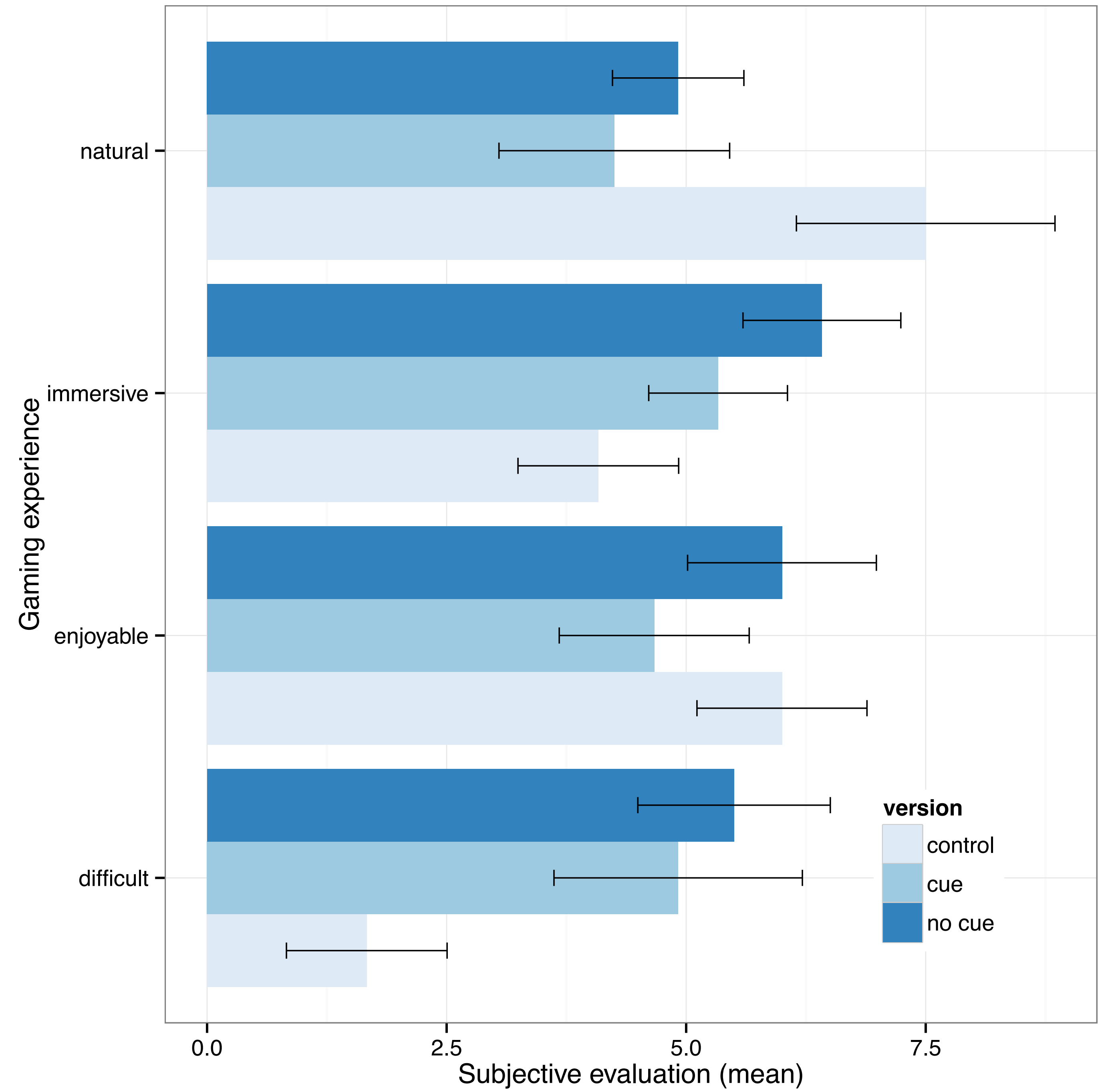
- Significant effects of game type:
  - naturalness

    (F(2, 22) = 12.49, p < 0.001)
  - immersion

    (F(2, 22) = 11.35,p<0.001)
  - enjoyment

    (F(2,22)=3.43, p=0.051)
  - difficulty

    (F(2,22)=19.94, p<0.001)



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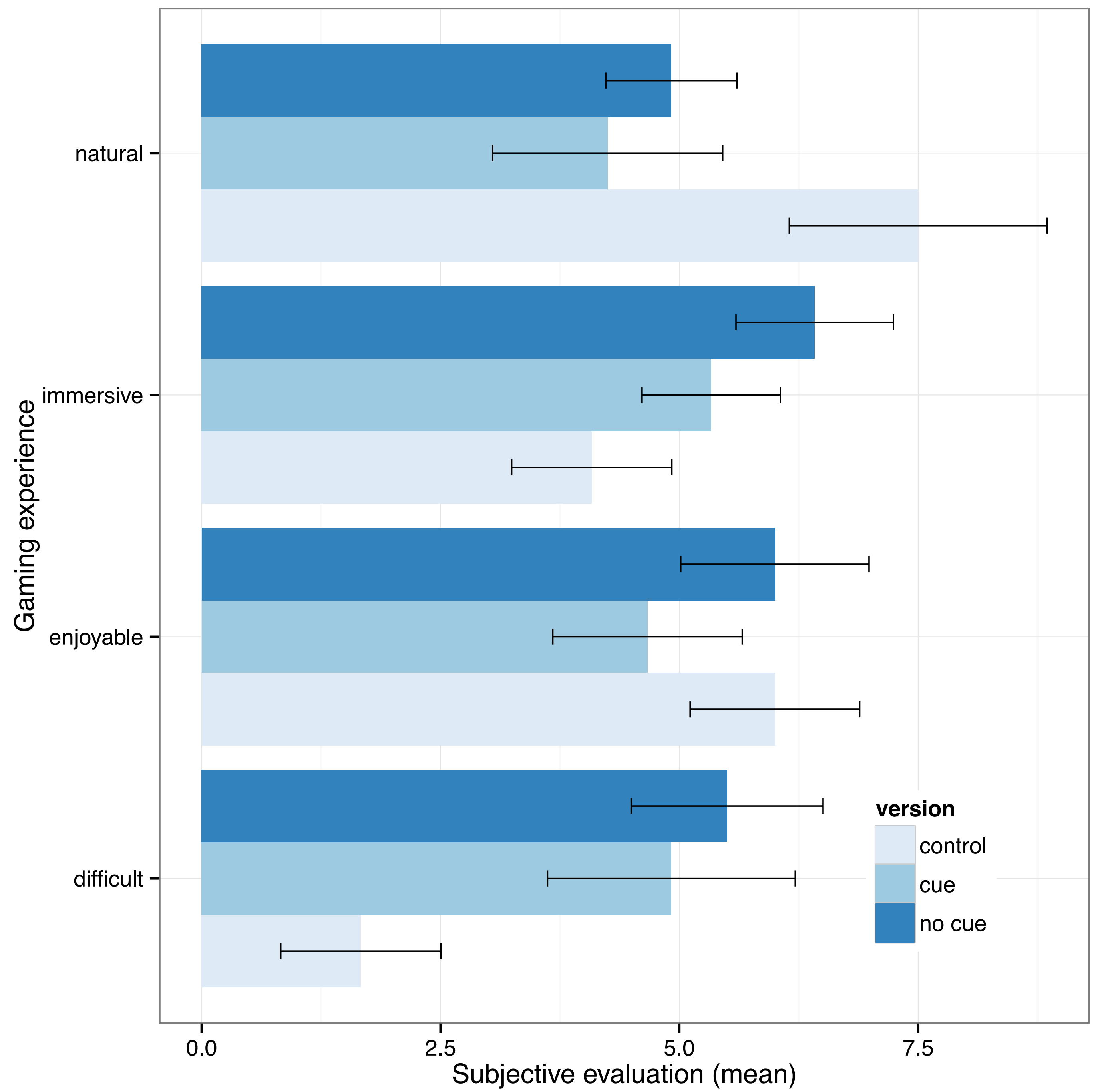
GAME EXPERIENCE EVALUATION

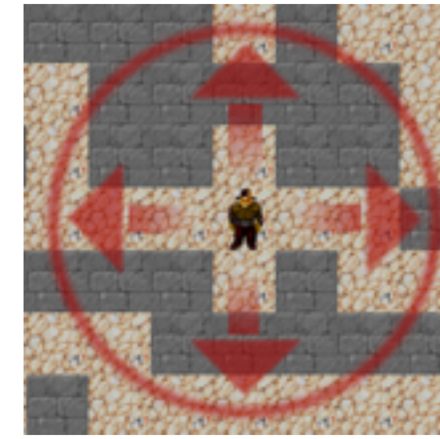
- Gaze-contingent interaction with no cues more difficult
    - but also more immersive than keyboard
- Gaze-contingent interaction with visual cues (vs. keyboard):
    - less enjoyable
    - less natural
    - more difficult



SUMMARY

- Contrary to our hypotheses no impact of gaze control on indicators of users' cognitive load, but…
- Negative impact on:
  - performance (longer completion times), and
  - gaming experience (less enjoyable and less immersive)

DISCUSSION & FUTURE WORK



- Gaze-controlled games prevent visual scanning
    - instance of the classical Midas Touch problem (likely to lower the gaming experience)
- Improved overt gaze cueing would allow switching between modes:
    - gaze-controlled gaming and
    - visual field scanning
- Similar in spirit to Snap-Clutch

DISCUSSION & FUTURE WORK

- We suggest **V-pad:**
  - a system in which the movement of the game character is controlled only
    - when gaze is within a given radius of the character's position
  - when gaze falls outside this radius, game switches to visual scanning mode