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

With cues vs. no cues:

- Hard maze with cues vs. hard maze with no cues
- Easy maze with cues vs. easy maze with no cues
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
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
PERFORMANCE

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

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 \( (F(2,16) = 1.11, p > 0.1) \)
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)
  - affords local saccades from game character to arrows (smaller deviations from optimal path)

or

- affords visual exploration to find optimal path (larger deviations from optimal path)
- 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
    \( (F(2, 22) = 19.94, p < 0.001) \)
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