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Inducing and Detecting Anchoring Bias via Game-Play in Time-extended Decision-Making Tasks

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Outline

- Motivation
- Inducing and Detecting Anchoring Bias
- Experimental Setup with Human Subjects
- Results and Analysis
- Lessons Learned and Future Work

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Motivation

- Cognitive biases in decision-making are known to affect and possibly degrade a decision outcome's value to the decision maker
- Specific type of cognitive bias studied: Anchoring bias
- Research Question: Does anchoring bias have a time-extended effect on human decision-makers?

Background on Anchoring Bias

- Anchoring bias [Tversky and Kahneman(1974)]
- Humans rely heavily on an initial piece of information, called an anchor
- Tend to overlook information while making subsequent decisions that could have led to better choices
  - Instead, gravitate towards choices that align with the anchor.

Amos Tversky and Daniel Kahneman. 1974. Judgment under uncertainty: Heuristics and biases. Science 185, 4157 (1974), 1124–1131.

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Related Work

- Later studies of anchoring bias moved towards successively made decisions
  - Perceived loudness of sounds played in succession [Jesteadt et al.(1977)],
  - Group decision-making [Stewart et al.(2006), Herzog and Hertwig(2011)],
  - Computer gaming [Gobet and Simon(1996), Doucet et al.(2021)]
  - Facial attractiveness and ringtone likeability [Huang et al.(2018)],
  - Financial decision-making [Ni et al.(2019)],
  - Reviews of books and college applications [Talkad Sukumar et al.(2018),
  - Vinson et al.(2019), Echterhoff et al.(2022)].
- Tasks arrive in a sequence; task remained same, but task attributes changed
- Decision is a function of the current task's attributes
- Anchoring bias of the decision-maker is claimed if:
  - Bypass or make a shortcut through the function that maps the attribute values to the decision outcome,
  - How? Used a previously encountered task's decision outcome to determine the current task's decision outcome.

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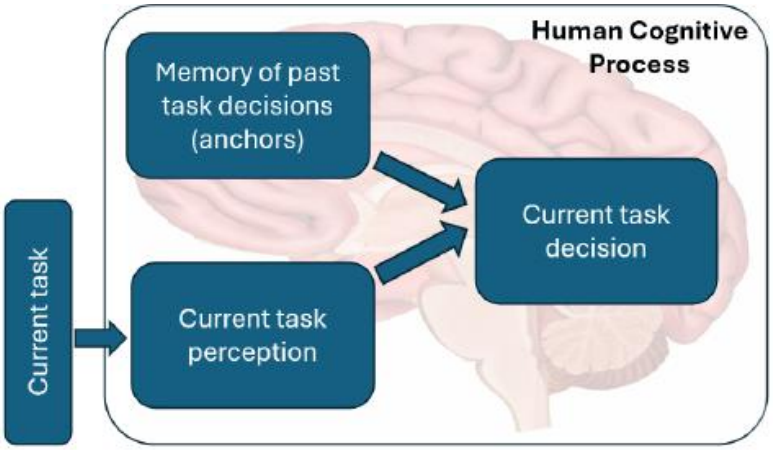
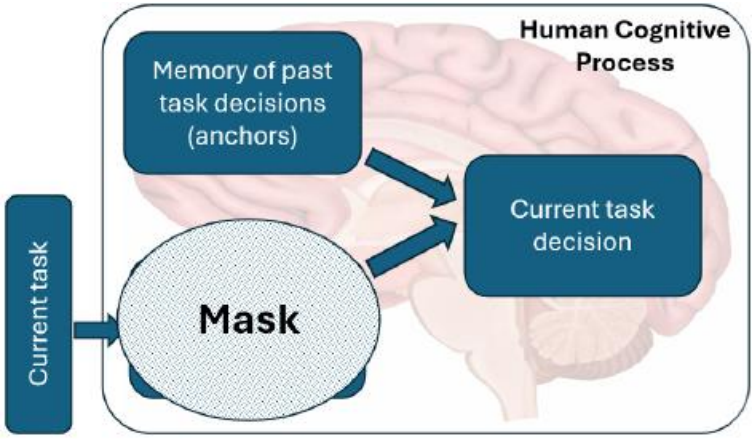
Our Contribution

- Existing research: While making the decision for the current task the decision maker has access to:
  - features of the current task
  - experience from past decisions
- Our research: While making decision, decision maker has
  - No access to the current task's features
  - Rely solely on experiences from memory from similar tasks to make decisions,
- Is anchoring bias still present?





INDUCING AND DETECTING ANCHORING BIAS VIA GAME-PLAY

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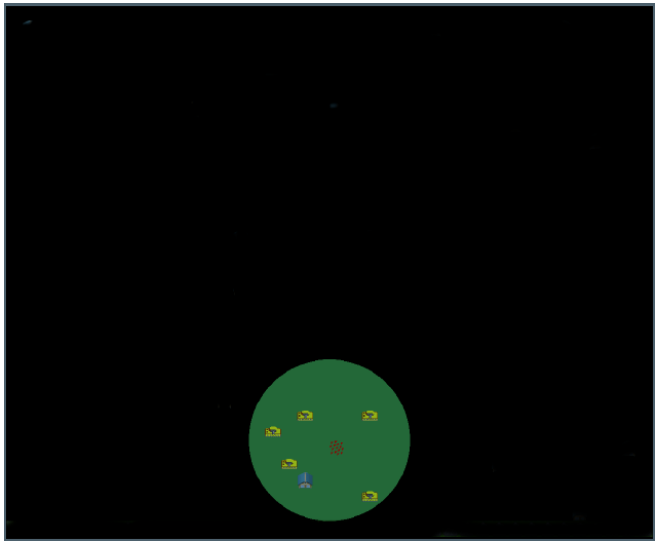
Game-Play for Anchoring Bias Detection

- Gamified environment
- Multiple tanks are placed at random locations inside a field
- Player has a movable game piece – moves with cursor
- Player can only see portion of game field within a viewport centered at the location of the game piece
- Objective: Search the field to locate and clear (destroy) all tanks, exit the field through the egress



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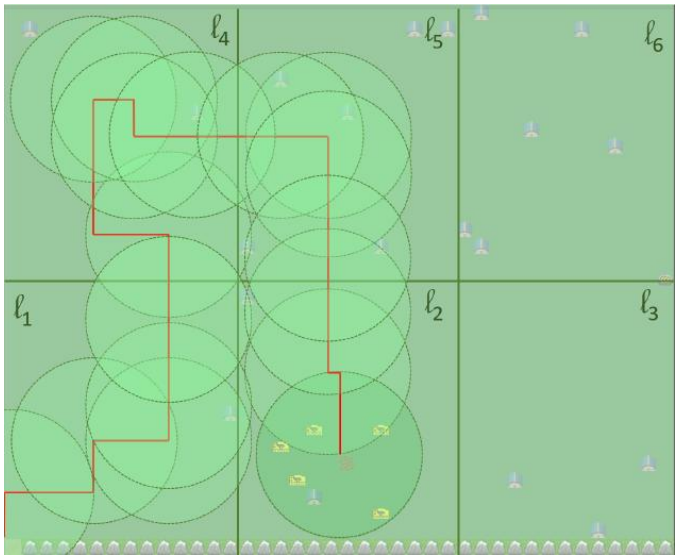
Game-Play for Anchoring Bias Detection

- Player cannot see locations of tanks at the start of the game
  - Tanks are located in a cluster for simplicity
- Has to move game piece to search for tanks
  - Via cursor: UP, DOWN, LEFT, RIGHT
- Cursor movement done by player recorded in the form of a trajectory
- Other points:
  - Game field divided into disjoint cells for simplifying trajectories
  - Location of the tank cluster could change between games
  - Termination criteria:
    - All tanks cleared + game piece exits field via egress
    - No. of moves exceeds allowed number of moves



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Inducing Anchoring Bias

- Experiment is divided into two phases for playing the game:
  1. Anchoring Phase
  2. Evaluation Phase
- Multiple rounds of the phases (anchoring followed evaluation)
- Player does not know when one phase ends and the other begins

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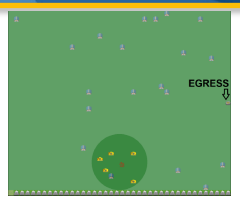
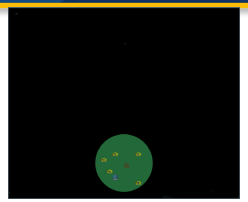
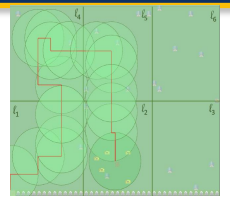
Anchoring Phase



- Idea for anchoring: Make the player believe that the tanks will always be in more or less the same region
- Tank location during anchoring phase serves as the *anchor*
- Anchoring runs:
  - Game piece placed in the start cell (bottom left cell)
  - Tanks are placed in one of the remaining cells (player does not know which cell has the tanks), called anchor cell
  - Player plays game until a termination criterion is met (all tanks cleared + egress OR exceeded no. of allowed cursor moves)
  - After that, game is reset
    - Game-piece goes back to start cell
    - Tanks returned to the same cells (unknown to player)
- Player is allowed to play n_{anc} anchoring runs
- Player does not know the value of n_{anc}

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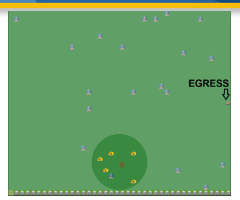
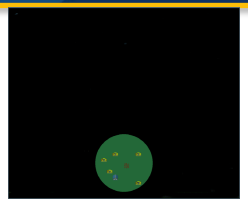
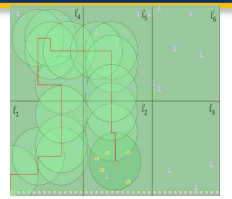
Evaluation Phase



- Idea for evaluation: Place the tanks in different cells in different runs to see:
  - Was the player anchored ?
    - Goes towards the anchor cell first to look for tanks
  - How long did the anchoring effect last?
    - How many runs the player keeps going to the anchor cell first to look for tanks
- Tanks can now be placed in any of the cells, *except* the start cell or the anchor cell
- Player plays n_{eval} evaluation runs
- At the end of each run
  - Game piece is reset to start cell
  - Tanks are placed in a randomly selected cell besides the start cell or anchor cell

EXPERIMENT SETUP WITH HUMAN SUBJECTS

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Experiments with Human Subjects

- Human subjects from U.S. Navy and Marine personnel at the Naval Aerospace Medical Institute (NAMI), Pensacola, FL, USA.
- 74 human subjects (players) asked to participate on a voluntary basis
- Informed consent and demographic data collected from each player.
- Average age range between 21 – 23 years
- Each player given a tutorial at the start of their session
- Each session comprised 2 rounds of:
  - 5 anchoring runs
  - 2 evaluation runs

RESULTS AND ANALYSIS

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Game-Play Data Analysis

- Game play data collected in the form of trajectories
  - Sequence of <cell location, cursor movement>
- Trajectories analyzed to determine anchoring
- Outline of trajectory analysis algorithm:
  - If the player's trajectory visited a cell not on the shortest path connecting the start cell to the anchor cell, then player was not anchored
  - If the player's trajectory stayed within the cells along the shortest path but loitered around or took detours within the cells, then player was not anchored
  - Otherwise, player was anchored
- Based on the *Jesteadt-Luce-Green* model for anchoring bias

Walt Jesteadt, R Duncan Luce, and David M Green. 1977. Sequential effects in judgments of loudness. Journal of Experimental Psychology: Human Perception and Performance 3, 1 (1977), 92

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Research Questions

- Time-effect of Anchoring
  - RQ1: How long does the anchor influence decisions after the anchor is removed?
  - RQ2: If the anchor is reintroduced later on, does the subject get re-anchored?
- Psychological effect of Anchoring
  - RQ3: Is *anchoring propensity* shown by a subject during anchoring runs an indicator of the subject's getting anchored in evaluation runs?

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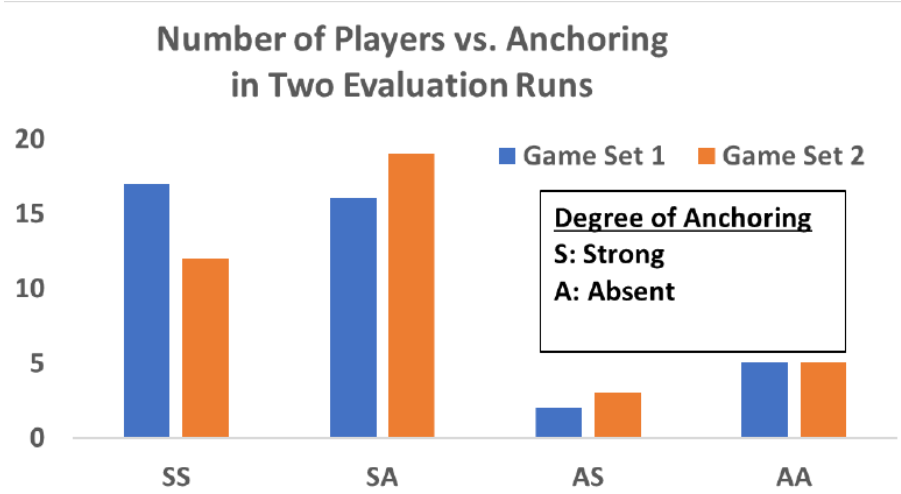
Time Effect of Anchoring (1)

RQ1: Do subjects show anchoring bias after 5 anchoring runs?



- 79 valid data instances (after removing unusable data, incomplete game-runs)
- x-axis: degree of anchoring (strong vs. absent) in run 1 followed by run 2.

- Experiments showed a strong evidence of anchoring bias
- 81% of subjects (64 out of 79 data instances) had been anchored either in both or only in the first evaluation runs.
- Very little variation (~6%) in the number of subjects anchored across the two game runs

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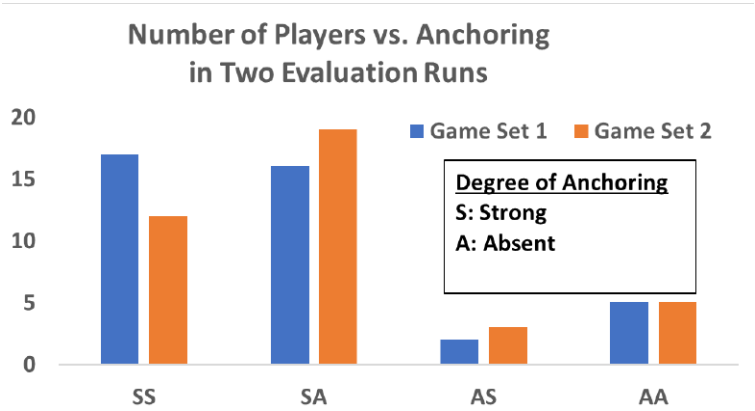
Time Effect of Anchoring (2)

RQ2: Does anchoring bias, if present, last for more than one evaluation run?

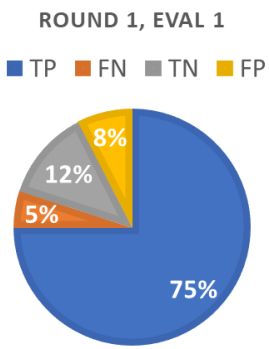


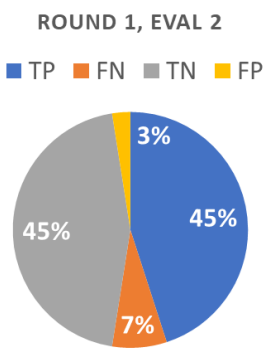
- 79 valid data instances (after removing unusable data, incomplete game-runs)
- x-axis: degree of anchoring (strong vs. absent) in run 1 followed by run 2.

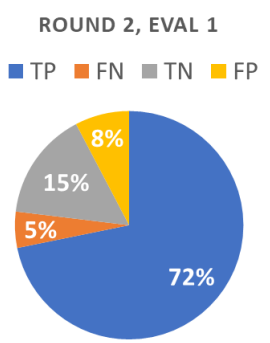
- Compared number of data instances that showed strong anchoring only in the first evaluation run (labeled SA in figure) versus those that showed strong anchoring in both evaluation runs (labeled SS in figure).
  - 35 instances: anchoring decreased between first and second evaluation runs
  - 29 instances: anchoring remained strong between first and second evaluation runs
- Conclusion: small but non-negligible support that effect of anchoring bias diminishes if the player gets information that contradicts the anchor (during evaluation runs).
- Anomaly: Playing more games leads to fatigue that encourages shortcuts leading to reliance on biases, but we found less reliance on biases in later games

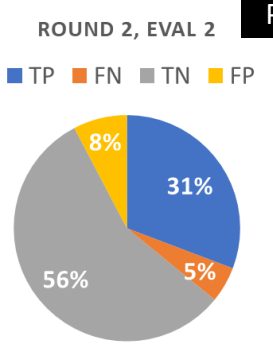
Psychological Effect of Anchoring

RQ3: Does a subject that is showing a propensity towards anchoring bias during anchoring runs, actually show anchoring bias in evaluation run(s)?









Predicted by JLG model

From experiment data

Notation	Anc. Bias Propensity	Anc. during eval runs
TP	✓	✓
FN	X	X
TN	✓	X
FP	X	✓

- Model accuracy of 80% and 77% in first evaluation runs (Rnd 1, Eval 1 and Rnd 2, Eval 1)
- Model accuracy of 52% and 36% in second evaluation runs (Rnd 1, Eval 2 and Rnd 2, Eval 2)
- Conclusions:
- As the player plays more sets of anchoring + evaluation runs, the anchoring propensity during anchoring runs cannot be used as an indicator to predict if the player will get anchored during evaluation run
- Beyond two evaluation runs, the prediction model was not relevant any more (accuracy diminished below 50%)

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Lessons Learned

- Diminishing effect of anchor
- Ergonomic Factors Affecting Human Subjects
- Access to Human Subjects
- Bias Naming
- Underlying Cause for Bias

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Conclusions and Future Work

- Main takeaways:
  - Past anchors significantly influence immediately future decision choices.
  - But this influence diminishes as the decision maker is exposed to information contrary to the anchor.
  - But if the same decision maker is subsequently exposed to another anchor, anchoring bias is again observed, albeit with lesser effect than the first anchor.
- Future work:
  - Effect of external and extraneous factors on anchoring bias:
    - Distractions and deceptions (e.g., mobile non-playing characters, tank-like objects that aren't real tanks)
    - Task complexity (e.g, clear tanks at multiple clustered locations in a larger map)
    - Multi-level decisions (e.g., while clearing tanks, explore the houses to retrieve a hidden key that let's the player unlock the egress from the game)
    - Presence of teammates and/or adversaries in the game
- Techniques for mitigating anchoring bias via automated decision aids to guide the decision maker towards less-biased decisions in real-time.

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