* In this project we studied human decision-making behavior, while participants performed either a visual or manual search task.

**Introduction**

* The idea behind this project was based on findings from one recent study, where human participants showed very similar exploration patterns when free-viewing images of naturalistic scenes or exploring the same images, while using finger taps to uncover regions of interests within the images.
* However, another study found striking differences in visual and manual exploration patterns while participants performed a foraging task, presumably due to the higher metabolic and temporal costs of manual actions.
* The goal of this project was to further explore similarities and difference in exploration behavior, and to compare the optimality of decision-making across different effectors.

**Methods**

* For this, we have built a paradigm that combined a search and discrimination task.
  + In each trial of our paradigm, we showed participants a search display that was made out of two target stimuli and eight distractors.
  + We instructed participants to find one of the targets, and to report the position of a gap that was located on one of the four sides of the target’s rectangular element.
    - Critically: in each trial, participants could freely choose which target they want to search and discriminate.
* We rewarded participants for correct responses, penalized them for incorrect ones, and participants were given 6 minutes and 30 seconds to complete as many trials as they can.
  + After the experiment participants received however much reward they have accumulated as a bonus payout, so they had not only some incentive to perform well in our task, but also to optimize their behavior, in order to maximize how much reward they can take home.
* Overall, our experiment had two conditions, in which participants either used eye movements (visual search condition) or finger taps (manual search condition) to search for targets, and to reveal if a stimulus was a target or disctrator.
* Within each condition, we manipulated two things:
  + First, we manipulated the discrimination difficulty of targets by varying the size of the gap.
  + Second, the prospective time it takes to find one or the other target by varying, unpredictably in each trial, how many distractors shared a color with each distractor.
* So, to maximize their bonus payout, participants had to, in each trial, make a decision about which target to search for, and for this, consider the prospective gain of target options (ration between the probability to get a reward and time it takes to find a target).

**Results**

* In a first step we checked, which factors participants considered when choosing between targets, and if they made sensible decisions.
  + For this, we fitted linear regressions to the choice curves of participants and analyzed normalized intercepts and slopes of the resulting fits.
  + We found that that most participants had positive intercepts, signifying an initial preference for easy targets, and negative slopes, signifying a change in the target preference as search costs increased.
  + 🡪 So, participants not only considered the relative discrimination difficulty of targets, but they also adapted their preference to variations in the relative search costs of target.
    - And this effect was present for both, visual and manual search.
* After establishing how participants choose which target to search and discriminate, we next analyzed how participants searched for targets.
  + For this, we analyzed which stimuli participants inspected in trials.
  + We found that participants, across both conditions, had a strong preference to preferentially inspect stimuli from the set of the target, which they eventually chose to discriminate in the trial.
    - However, this preference was more pronounced in the manual, compared to the visual search condition, and this difference was especially striking for the first movement participants made in a trial.
* The final question we can now ask is: behaving the way did they did, did participants manage to maximize their bonus payout?
  + To test this, we generated ideal observer predictions about the average gain participants should achieve if acting like an ideal observer, and compared them to participants’ empirical gain.
  + We found that while participants in the manual search condition did indeed act close to the predictions of an ideal observer model, and, by this, maximized their bonus payout, participants in the visual search condition fell short of the ideal observer predictions.
* Fitting a probabilistic model to the data of participants revealed that the suboptimal behavior in the visual search condition was due to noise on two behavioral levels.
  + 🡪 Noise at the decision level corrupted decisions about which target to search for, so that participants did not always chose the higher-gain target, but occasionally also chose the lower-gain targets.
  + 🡪 Noise at the fixation level, on the other hand, corrupted decisions about which elements to inspect while searching for targets, so that participants not only inspected elements from the set of the chosen target while searching for the target, but they occasionally also inspected elements from the non-chosen set, by which they wasted time, in which more trials could be completed.

**Conclusion**

* To conclude, we found that participants in our task strived to optimize their behavior, and, by this, maximize their bonus payout.
  + And they did this, no matter which effector we forced them to use during search.
* However, the performance of our participants was constrained by noise on different behavioral levels, and the influence of noise was considerably more pronounced for visual than for manual search.
  + 🡪 One reason for this might be the slower time course of manual actions, which makes them less susceptible to noise compared to fast-paces eye movements.