

Preregistration for Quantitative Research in Psychology (PRP-QUANT) Template

Title

T1 Title
The title should be focused and descriptive, using relevant key terms to reflect what will be done in the study. Use title case (https://apastyle.apa.org/style-grammar-guidelines/capitalization/title-case).
Using individual differences to understand saccade-pursuit interactions

T2 Contributors, Affiliations, and Persistent IDs (recommend ORCID iD)
Provide in separate entries the full name of each contributor, each contributor's professional affiliation, and each contributor's persistent ID. See ORCID iD for an example of persistent ID (https://orcid.org/). Optional: include the intended contribution of each person listed (e.g. statistical analysis, data collection; see CRediT, https://casrai.org/credit/).
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T3 Date of Preregistration
This is assigned by the system upon preregistration submission.

T4 Versioning information

This is assigned by the system upon submission of original and subsequent revisions. Should be a persistent identifier, if not a DOI.

T5 Identifier

This unique identifier is assigned by the system upon submission.

T6 Estimated duration of project

Include best estimate for how long the project will take from preregistration submission to project completion.

1-1.5 years

T7 IRB Status (Institutional Review Board/Independent Ethics Committee/Ethical Review Board/Research Ethics Board)

If the study will include human or animal subjects, provide a brief overview of plans for the treatment of those subjects in accordance with established ethical guidelines. If appropriate institutional approval has been obtained for the study, provide the relevant identifier here. If the study will be exempt from ethical board review, provide reasoning here.

Experimental procedures have been reviewed by the ethics board of the Justus-Liebig university Giessen: LEK FB06 2017-08

T8 Conflict of Interest Statement

Identify any real or perceived conflicts of interest with this study execution. For example, any interests or activities that might be seen as influencing the research (e.g., financial interests in a test or procedure, funding by pharmaceutical companies for research).

No Conflict of Interest

T9 Keywords

Include terms specific to your topic, methodology, and population. Use natural language and avoid words used in the title or overly general terms. If you need help with keywords, try a keyword search using your proposed keywords in a search engine to check results.

Eye movements, Individual differences, Saccades, Pursuit

T10 Data accessibility statement and planned repository

"We plan to make the data available (yes / no)

If "yes", please specify the planned data availability level by selecting one of the options:

- Data access via download; usage of data for all purposes (public use file)
- Data access via download; usage of data restricted to scientific purposes (scientific use file)
- Data access via download; usage of data has to be agreed and defined on an individual case basis
- Data access via secure data center (no download, usage/analysis only in a secure data center)
- Data available upon email request by member of scientific community
- Other (please specify)

Yes, Data access via download; usage of data for all purposes (public use file)

T11 Optional: Code availability

We plan to make the code available (yes / no).

If "yes", please specify the planned code availability level (use same descriptors of data in T10).

Yes,
Code access via download; usage of data for all purposes (public use file)

T12 Optional: Standard lab practices

Standard lab practices refer to a (timestamped) document, software package, or similar, which specifies standard pipelines, analytical decisions, etc. which always apply to certain types of research in a lab. Specify here and refer to at the appropriate positions in the remainder of the template:

We plan to make the standard lab practices available (yes / no).

If "yes", please specify the planned standard lab practices availability level (use same descriptors of data in T10).

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Abstract

(150 words)

A1 Background

(See introduction I1)

Due to the foveal organization of our visual system, eye movements are an essential part of perception and are studied across a wide range of different research areas. Across all areas typically only saccadic or only pursuit eye movements are measured in different tasks and behavior is averaged across observers.

A2 Objectives and Research questions

(See introduction I2)

In this study we want to use interindividual variability to understand the naturally occurring saccade-pursuit interactions.

A3 Participants

(See methods M4)

A large group of participants will perform a set of standard oculometric (saccade and pursuit) and psychometric measurements with different relevant sensory information (position and velocity).

A4 Study method

(See methods M10-14)

We will correlate these basic measurements across observers with differences in saccade-pursuit interactions to understand which factors drive behavioral differences. We want to test whether interindividual difference vary across different eye movements or across different relevant sensory information to gain insight into the structure of the oculomotor system.

Introduction

(no word limit)

I1 Theoretical background

Provide a brief overview that justifies the research hypotheses.

Due to the foveal organization of our visual system, eye movements are an essential part of perception and are studied across a wide range of different research areas (see Klein & Ettinger, 2019). The focus of eye movement research is mostly on average behavior and research is often specialized for either saccadic or pursuit eye movements (see Goettker & Gegenfurtner, 2021). For example, isolated saccades are mainly studied during reading (e.g. Engbert et al. 2005) or viewing of images (e.g. Kümmerer et al., 2016). One thing that most lines of saccadic research have in common is static visual input. In contrast, pursuit is studied with dynamic, moving stimuli, for example when it comes to the link between motion perception and pursuit accuracy (see Spering & Montagnini, 2011). While this previous research provided interesting insights into oculomotor control and perception, it is lacking two very important factors.

First, in natural behavior saccadic and pursuit always occur together and interact to allow optimal tracking (Orban de Xivry & Lefevre, 2007). It is also known that while saccades and pursuit are specialized for position- and velocity-errors, respectively, both eye movements use both kinds of information. Saccades to moving targets integrate velocity-information (e.g., Goettker et al., 2019) and pursuit is affected by position errors (e.g., Buonocore et al., 2019).

Second, while average behavior is informative, there are substantial and reliable individual differences in saccadic (Castelhano & Henderson, 2008) and pursuit eye movements (Versino et al., 1993). These interindividual difference are so strong and stable that they could be even used as an oculomotor signature (Bargary et al., 2017). Recently, using individual differences has gained a lot of traction in vision science (see Mollon et al., 2017) since it can allow fascinating insights into processing mechanisms. For example, Wilmer and Nakayama (2007) demonstrated that different phases of pursuit eye movements depend on different motion signals. They measured individual differences in two perceptual motion tasks and then correlated this with different phases of pursuit. and observed dissociation: While the low-level motion task correlated with pursuit initiation (0-100 ms after pursuit onset), the high-level motion task correlated with the later steady-state pursuit. This is in line with other interesting differences between pursuit phases, for example latencies to react to changes in visual stimuli are shorter during steady-state pursuit (Tavassoli & Ringach, 2009).

I2 Objectives and Research question(s)

Outline objectives and research questions that inform the methodology and analyses (below).

In this work we want to account for these two factors by investigating saccade-pursuit interactions with an individual difference approach. Recently, we observed that also how saccadic and pursuit eye movements interact differs across observers (Goettker et al., 2018). Saccade-pursuit interactions can be quantified as the combination of position and velocity errors that are necessary to trigger a corrective saccade during pursuit (de Brouwer et al., 2002). The combination of both error signals can be summarized in the eye crossing time (the time the target needs given its current position and velocity to cross the fixation location). Across different eye crossing times, it is then possible to map out a “smooth zone” for each observer, thus trials in which no additional corrective saccade is needed to track a target (Goettker et al., 2018). We found that some observers barely used corrective saccades for target movements that elicited corrective saccades for other observers in each trial. The overarching question is: Where do these differences come from?

To test this, we will measure a large group of observers in a series of standard saccade and pursuit paradigms as well as psychophysical judgements of changes in target position or velocity. We will use these measures then to predict saccade-pursuit interactions. To cover the whole space and avoid the isolated view on saccadic and pursuit eye movements, the response of both eye movements in response to position and velocity errors will be measured for each observer. Since there are substantial differences in the relevant signals for pursuit initiation and steady-state pursuit, we will measure saccade-pursuit interactions in both phases.

I3 Hypothesis (H1, H2, ...)

Provide hypothesis for predicted results. If multiple hypotheses, uniquely number them (e.g., H1, H2a, H2b,) and refer to them the same way at other points in the registration document and in the manuscript.

H1: We will be able to predict saccade-pursuit interactions based on individual differences in saccadic and pursuit eye movements.

H2: Saccade-pursuit interactions will differ during pursuit initiation and steady-state pursuit. We expect the center of the smooth zone to shift to shorter eye crossing times during steady-state pursuit.

H3: Saccade-pursuit interactions will be tailored to the strengths of each observer: Observers with good pursuit, will use it more and vice versa.

I4 Exploratory research questions (if applicable; E1, E2,)

If planning exploratory analyses, provide rationale for them here. If multiple exploratory analyses, uniquely number them (E1, E2, ...) and refer to them in the same way in the registration document and in future publications.

Given this rich and balanced data set, we will try to explore the structure of the data. Given that saccadic and pursuit eye movements are based on shared signals (Goettker & Gegenfurtner, 2021), we want to challenge the view that saccadic and pursuit eye movements belong to separate systems. We rather expect, that observers will vary across the relevant sensory information (position or velocity errors) tested in the different tasks.

Method

M1 Time point of registration

Select one of the options:

- Registration prior to creation of data
- Registration prior to any human observation of the data
- Registration prior to accessing the data
- Registration prior to analysis of the data
- Other (please specify; might include if T1 longitudinal data has been analyzed, but T2 has not yet been analyzed)

Registration prior to creation of data

M2 Proposal: Use of pre-existing data (re-analysis or secondary data analysis)

Will pre-existing data be used in the planned study? If yes, indicate if the data were previously published and specify the source of the data (e.g., DOI or APA style reference of original publication). Specify your level of knowledge of the data (e.g., descriptive statistics from previous publications), whether or not this is relevant for the hypotheses of the present study, and how it is assured that you are unaware of results or statistical patterns in the data of relevance to the present hypotheses.

No

Sampling Procedure and Data Collection

M3 Sample size, power and precision

(1) Relevant sample sizes: e.g., single groups, multiple groups, and sample sizes (or sample ranges) found at each level of multilevel data. (2) Provide power analysis (e.g. power curves) for fixed-N designs. For sequential designs, indicate your 'stopping rule' such as the points at which you intend to be viewing your data and in any way analyzing them (e.g., t-tests and correlations, but even descriptively such as with histograms).

- (1) Single group of observers performing all 8 subtasks
- (2) Based on previous results and expected correlations of around $r=.40$ (see Wilmer & Nakayama, 2007 for a related approach), a power analysis with a Type 1 error rate of $p = 0.05$ and a type 2 error rate of $p = .2$ results in 47 participants. Therefore, the goal is to collect data from 50 participants.

M4 Participant recruitment, selection, and compensation

Indicate (a) methods of recruitment (e.g., subject pool advertisement, community events, crowdsourcing platforms, snowball sampling); (b) selection and inclusion/exclusion criteria (e.g., age, visual acuity, language facility); (c) details of any stratification sampling used; (d) planned participant characteristics (gender, race/ethnicity, sexual orientation and gender identity, SES, education level, age, disability or health status, geographic location); (e) compensation amount and method (e.g., same payment to all, pay based on performance, lottery).

- a) standard methods of recruitment through subject pool etc.
- b) all healthy human subjects with normal or corrected to normal vision can take part in the study
- c) –
- d) Equal distribution of gender is preferable, no other factor needs to be monitored
- e) Compensation for all participants standard rate of 10 Euro per hour.

M5 How will participant drop-out be handled?

Indicate any special treatment for participants who drop out (e.g., there is follow-up in a manner different from the main sample, last value carried forward) or whether participants are replaced.

If participants drop out, they need to be replaced to reach the full sample size of 50 participants with a complete data set.

M6 Masking of participants and researchers

Indicate all forms of masking and/or allocation concealment (e.g., administrators, data collectors, raters, confederates are unaware of the condition to which participants were assigned).

There is no need for masking participants or researchers.

M7 Data cleaning and screening

Indicate all steps related to data quality control, e.g., outlier treatment, identification of missing data, checks for normality, etc.

Overall data quality during the experiment will be ensured through calibration procedures with the eye tracker (EyeLink 1000+). Missing information will be determined in the offline-analysis. Based on the mentioned criteria (see below) individual trials for each subtask might be excluded from the analysis.

M8 How will missing data be handled?

Indicate any procedures that will be applied during the analysis to deal with missing data, such as (a) case deletions; (b) averaging across scale items (to handle missing items for some); (c) test of missingness (MAR, MCAR, MNAR assumptions; (d) imputation procedures (FIML vs. MI); (e) Intention to treat analysis and per protocol analysis (as appropriate).

Individual trials might be excluded from the computation of average oculomotor or psychometric parameters for each individual in the respective subtask.

M9 Other information (optional)

For example, training of raters/participants or anything else not yet specified.

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Conditions and design

M10 Type of study and study design

Indicate the type of study (e.g., experimental, observational, crosssectional vs. longitudinal, single case, clinical trial) and planned study design (e.g., between vs. within subjects, factorial, repeated measures, etc.), number of factors and factor levels, etc..

Experimental study where each participant performs each subtask (within-design). There are a total of 8 subtasks that participants have to perform.

M11 Randomization of participants and/or experimental materials

If applicable, describe how participants are assigned to conditions or treatments, how stimuli are assigned to conditions, and how presentation of tests, trials, etc. is randomized. Indicate the randomization technique and whether constraints were applied (pseudo-randomization). Indicate any type of balancing across participants (e.g., assignments of responses to hands, etc.).

Order of subtasks will be randomized across participants. Within each subtask, all variations and conditions are also presented in randomized order.

M12 Measured variables, manipulated variables, covariates

This section shall be used to unambiguously clarify which variables are used to operationalize the hypotheses specified above (item I3). Please (a) list all measured variables, and (b) explicitly state the functional role of each variable (i.e., independent variable, dependent variable, covariate, mediator, moderator). It is important to (c) specify for each hypothesis how it is operationalized, i.e., which variables will be used to test the respective hypothesis and how the hypothesis will be operationally defined in terms of these variables. The description here shall be consistent with the statistical analysis plans specified under AP6 (below).

For each of the subtasks standard oculometric or psychometric parameters will be extracted:

1. Saccade-Static: Saccade latency, accuracy (2D, horizontal, vertical), precision (ellipse area)
2. Saccade-Moving: Saccade latency, accuracy (2D, horizontal, vertical), precision (ellipse area)
3. Pursuit – Moving: Pursuit gain during open-loop (0-100 ms after pursuit onset) and closed-loop (200-300 ms after pursuit onset), pursuit latency
4. Pursuit – Static: Latency and maximum deviation in eye velocity after presentation of position cue
5. Psychometric- Static: PSE & JND for detection of different positions
6. Psychometric- Moving: PSE & JND for detection in different velocities
7. Smooth Zone Initiation: Mean, SD and Amplitude of fitted Gaussian to saccade probabilities across different target crossing times
8. Smooth Zone Steady-State: Mean, SD and Amplitude of fitted Gaussian to saccade probabilities across different target crossing times

M13 Study Materials

Please describe any relevant study materials. This could include, for example, stimulus materials used for experiments, questionnaires used for rating studies, training protocols for intervention studies, etc.

All relevant study material will be presented on-screen and will be standardized across participants. At the beginning of each subtask, participants will receive a written instruction of the upcoming task and then the experiment will be presented on screen. The experiment will differ across the different subtasks:

1. Saccade-Static: After an initial fixation at the bottom of the screen (10 deg vertical shift), a target will be presented at the vertical center of the screen and horizontally six different positions (± 3.75 deg, ± 2.5 deg, ± 1.25 deg). These positions matches the position the target will have in subtask 2 after 250 ms.
2. Saccade-Moving: After an initial fixation at the bottom of the screen (10 deg vertical shift), a target will be presented at center of the screen and move horizontally to the left or right with one of three different velocities (5, 10 or 15 deg/s).
3. Pursuit – Moving: Participants will fixate a central target which will step to the left or right and immediately moves into the opposite direction with one of three different velocities (5, 10 or 15 deg/s). The size of the step will be adapted so that the target crosses the initial fixation point after 200 ms.
4. Pursuit – Static: Participants will fixate a central target which will step 2 deg to the left or right and immediately moves into the opposite direction with 10 deg/s. After 350 ms after motion onset a positional cue will be presented before or behind the tracking target (see Bounocore et al., 2019).
5. Psychometric- Static: Participants need to compare the position of a currently presented target to a memorized standard target. The standard target will be presented at 2 deg. The comparison targets will be presented at 1.68, 1.84, 2, 2.16, or 2.32 deg.
6. Psychometric- Moving: Participants need to compare the velocity of a currently presented target to a memorized standard target. The standard target will be presented at 10 deg/s. The comparison targets will be presented at 8.4, 9.2, 10, 10.8, 11.6 deg/s.
7. Smooth Zone Initiation: Participants will fixate a central target which will step to the left or right and immediately moves into the opposite direction with 10 deg/s. The size of the initial step will be varied to manipulate the time the target takes until it crosses the initial fixation position (50, 100, 150, 200, 250, 300, 350 ms).
8. Smooth Zone Steady-State: Same as in 7, however here the critical step to measure saccade-pursuit interaction will occur while participants are already pursuing a target. The size of the step will be varied to manipulate the time the target takes until it crosses the initial fixation position (50, 100, 150, 200, 250, 300, 350 ms).

The target across all tasks is a Gaussian Blob with a standard deviation of 0.3 deg and a contrast of 0.2

M14 Study Procedures

Please describe here any relevant information about how the study will be conducted, e.g., the number and timing of measurement time points for longitudinal research, the number of blocks or runs per session of an experiment, laboratory setting, the group size in group testing, the number of training sessions in interventional studies, questionnaire administration for online assessments, etc.

Participants should complete all the subtasks in random order. Due to the estimated time for the individual subtasks, participants should complete 3-4 blocks per session. Each session should take about 1 hour, and participants will be asked to perform up to 3 sessions.

M15 Other information (optional)

Analysis plan

(NOTE: If this varies by hypothesis, repeat analysis plan for each)

AP1 Criteria for post-data collection exclusion of participants, if any

Describe all criteria that will lead to the exclusion of a participant's data (e.g. performance criteria, non-responding in physiological measures, incomplete data). Be as specific as possible.

If participants provide a complete data set with enough valid trials for each experiment (> 15 for each relevant factor combination), they will be used for the analysis.

AP2 Criteria for post-data collection exclusions on trial level (if applicable)

Describe all criteria that will lead to the exclusion of a trial or item (e.g. statistical outliers, response time criteria). Be as specific as possible.

Trials with blinks during the critical moments in the trial (when the target is present) will be excluded.

To ensure that participants react to the visual stimulus in a timely manner, trials with too short or too long latencies will be excluded (Saccades below 100 ms or higher than 500 ms; pursuit latencies below 50 ms and larger than 500 ms).

AP3 Data preprocessing

Describe all data manipulations that are performed in preparation of the main analyses, e.g., calculation of variables or scales, recoding, any data transformations, preprocessing steps for imaging or physiological data (or refer to publicly accessible standard lab procedure, cf. T12).

Raw eye movements traces will be filtered and the relevant eye movements (saccades and pursuit) will be detected in the data (see Goettker et al. 2019 for detailed procedure). Then the above-described parameters will be computed for each trial separately and then averaged for the respective condition.

For the psychophysical tasks we will fit psychometric curves for each participant and use the estimated parameters.

For saccade-pursuit interactions we will fit an inverse Gaussian to the proportion of saccades across the varying eye crossing times. The estimated parameters will be our measures of saccade-pursuit interactions.

AP4 Reliability analysis (if applicable)

Specify the type of scale reliability that will be estimated, whether it is internal consistency (e.g. Cronbach's alpha, omega), test-retest reliability, or some other form (e.g., a confirmatory factor analysis incorporating multiple factors as sources of variance). In a study involving measure development, researchers should specify criteria for removing items from measures a priori (e.g., largest factor loading magnitude, smallest drop in alpha-if-item removed).

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AP5 Descriptive statistics

Specify which descriptive statistics will be calculated for which variables. If appropriate, specify which indices of effect size will be used. If descriptive statistics are linked to specific hypotheses, explicitly link the information given here to the respective hypothesis.

We will compute the mean and standard deviation of all relevant measures for each experiment.

AP6 Statistical models (provide for each hypothesis if varies)

Specify the statistical model (e.g. t test, ANOVA, LMM) that will be used to test each of your hypotheses. Give all necessary information about model specification (e.g., variables, interactions, planned contrasts) and follow-up analyses. Include model selection criteria (e.g., fit indices), corrections for multiple testing, and tests for statistical violations, if applicable. Wherever unclear, describe how effect sizes will be calculated (e.g., for d-values, use the control SD or the pooled SD).

H1: To predict the saccade-pursuit interactions during initiation or steady-state we will perform multiple linear regressions based on the extracted parameters of the other experiments. We will also calculate pearson-correlations between the major outcome measure of subtasks (saccade accuracy for motion and position, pursuit gain for motion and change in gain for position, JND for position and motion) and the Smooth Zone measurements (center and minimum).

H2: We will perform a series of paired t-tests to compare the parameter of the fitted smooth zone between steady-state pursuit and pursuit initiation.

H3: We will perform paired t-tests between high and low performers for saccadic (defined in terms of accuracy) and pursuit (defined in terms of gain) tasks to test for differences in saccade-pursuit interactions.

AP7 Inference criteria

Specify the criteria used for inferences (e.g., p values, Bayes factors, effect size measures) and the thresholds for accepting or rejecting your hypotheses. If possible, define a smallest effect size of interest. If inference criteria differ between hypotheses, specify separately for each hypothesis and respective statistical model by explicitly referring to the numbers of the hypotheses. Describe which effect size measures will be reported and how they are calculated.

The default p-value is set to $p = .05$.

For the multiple regression we will look at the strength of each significant contributing factor.

When performing multiple t-tests, e.g., for H2 we will use the Bonferroni correction.

AP8 Exploratory analysis (optional)

Describe any exploratory analyses to be conducted with your data. Include here any planned analyses that are not confirmatory in the sense of being a direct test of one of the specified hypotheses.

To test for the structure of the data we will perform a factor analysis with following multidimensional scaling to look and interpret the relationships between the different tasks.

AP9 Other information (optional)

Other information optional

(NOTE: If needed, multiple lines with other information can be included)

O1 Other information (optional)

If there is any additional information that you feel needs to be included in your preregistration, please enter it here. Literature cited, disclosures of any related work such as replications or work that uses the same data, or other context that will be helpful for future readers would be appropriate here.

References

R1 References

Enter your references below. Use a consistent format (e.g., <https://apastyle.apa.org/style-grammar-guidelines/references/examples>)

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- Wilmer, J. B., & Nakayama, K. (2007). Two distinct visual motion mechanisms for smooth pursuit: evidence from individual differences. *Neuron*, 54(6), 987-1000.

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To receive a timestamp and a DOI (digital object identifier), submit your preregistration protocol to **PsychArchives** via <https://pasa.psycharchives.org/>, preferably as PDF.