Does varying cue-stimulus interval affect the sensory discrimination performance in the antisaccade task?

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Author Note

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All code and data used in performing this research are publicly available at `https://github.com/bartekkroczek/PhD`

The authors made the following contributions. Bartłomiej Kroczek: Conceptualization, Formal Analysis, Investigation, Methodology, Software, Visualization, Validation, Writing - Original Draft Preparation, Writing - Review & Editing; Adam Chuderski: Conceptualization, Methodology, Writing - Review & Editing, Supervision.

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Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words "**here we show**" or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: attentional vigilance, antisaccade task, processing speed

Word count: X

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Introduction

The human ability to direct cognitive processing to specific objects and events (both external and internal), while ignoring some other objects and events, has been commonly conceptualized as "attention." Almost since the advent of psychology (it is worth mentioning the famous note on attention by James (1890) or Lectures on the elementary psychology by Titchener (1908)), and especially with the beginning of cognitive psychology (Broadbent, 1957), various functions and processes of attention have been identified and studied. They included (e.g.,Pashler, 1998, ...) such functions as selective attention (focusing, or amplifying, a selected stream of perception at the cost of attenuating alternative streams), attentional search (looking for objects matching a predefined template; cit.), sustained attention, or vigilance (maintaining a high level of arousal for prolonged time periods in order to detect rare events), and attention shifting (frequently switching between two or more channels, tasks, and/or modalities, or even trying to process them concurrently).

More recently, researchers have hypothesized (e.g., Engle, 2002; . . .) that attention can be responsible for the control over cognitive processing (a faculty called attentional control, or executive control, or cognitive control), organizing such processing around a goal at hand, while blocking goal-irrelevant or even distracting information. The latter function is typically called "inhibition" (cit.), understood as an active stopping of percepts, memory retrievals, and responses. The present work, instead of a particular function, examined a more general property of attention, playing a role across multiple attentional functions, such as selection, vigilance, shifting, and control. Specifically, it was analyzed whether and how the efficiency of attention depends on the time allowed for a given attentional process to unfold, that is, the time (henceforth called cue-stimulus interval, CSI) elapsing between the moment at which the attention system learns that its maximum involvement will be needed and the onset of an event for which such an involvement is necessary. The efficiency of attention was operationalized in terms of accuracy and latency of discrimination of a hardly detectable stimulus, which without valid directing of attention would remain unidentified. Specifically, we applied the well-known antisaccade task, which requires diverting the eye gaze from an intensive stimulation that automatically attracts attention, and instead directing the gaze to the proper object (shown briefly). The crucial variable manipulated throughout our three studies consisted of the CSI between start of the antisaccade task trial (centered fixation cross) and the onset of the to-be-ignored stimulation at one side of the screen, accompanied by the presentation of to- be-detected object at the opposite side of the screen. Three studies differed in the range and resolution of the CSI applied, as there exist a trade-off between these two parameters (i.e., given reasonable duration of an experiment, increasing the range requires decreasing the resolution, and vice versa). Why is analyzing the effect of CSI on attentively demanding discrimination of a stimulus important? It is important, because it is a crucial marker for how the attentional system may be functioning. In other words, it is the litmus paper for major theories of attentional mechanisms, allowing to provide potentially supporting evidence for some of them, while casting doubts for others. To briefly mention the most influential predictions on the variation of discrimination efficiency as a function of CSI, there seem to exist at least three predicted patterns. The first pattern could consist of a decreasing discrimination efficiency with increasing CSI, as if immediately alerted attention faded away with time (due to habituation, fatigue, or consumption of some neural resource, etc.; cits). Such a pattern might indicate that attentional mechanisms are time limited, and the maximally active focusing of attention is possible only for brief periods of time. Alternatively, discrimination efficiency might increase with increasing CSI, if it requires voluntary build-up in the mind of the goal or task representation needed to direct the subsequent cognitive processing. Such a pattern would be consistent with top-down, controlled accounts of attention (e.g., cits). Finally, recent models of attention (e.g., cits) proposed its functioning to be strictly rooted in underlying neural oscillations, and as a result attention should fluctuate periodically, interleaving a stronger focusing on a given object with a stronger tendency to switch away from it (e.g., switch to another object or modality, cits). These oscillatory models predict the periodic variation in discrimination efficiency across the CSI range, ideally at a stable frequency. Of course, one could also observe no meaningful pattern of variations in stimulus discrimination efficiency, which might indicate that no existing theory provides a sufficiently plausible and coherent explanation of the functioning of attention, and so we need a novel theory of how attention operates. The present work is structured in the following way. Chapter 1 presents the major theories predicting that attentional modulation of cognitive processing varies in time. Chapter 1 also reviews available evidence on temporal characteristics of attention, which has grown exponentially in recent years. Chapter 1 ends with the key research questions. Chapter 2 presents the adopted method – the antisaccade task with varying CSI. The chapter describes three experiments which applied this task. As the observed null results seem problematic for most of existing theories of the attention variability, a detailed methodological and theoretical analyses of existing literature are carried out in Chapter 3. These analyses suggested that at least some part of existing data were invalidly modeled and interpreted, and the presumed evidence for each of the respective theories might be more weakly supported than is commonly believed. In order go beyond the limitations of existing methods, in Chapter 4 we replicate and extend the very recent experiment by Rouder et al. (in press?). The results suggest that – contrary to widespread opinion – stimulus discrimination in the antisaccade task might not be capturing functioning of attention, but may reflect some other, less transient individual characteristics of the cognitive system. Chapter 5 provides the general discussion of our empirical and methodological work, with implications and future veins of research on attention.

Rozdział 1

ssss

Tu mam najtrudniej, bo złapałem się na luce w rozumieniu. Jaki - z naszej perspektywy - jest związek między attentional vigilance a cognitive control? Czemu torturując zadanie antysakadowe które ma być miarą kontroli wysnuwamy wnioski o uwadze? To jest tak, że cognitive control to jakiś puzel, który służy do budowania teorii jak działa uwaga (i pewnie nie tylko)?

Pomijając powyższe, wyobrażam sobie takie fakty:

- Argumenty za tym, że uwaga jest zmienna w czasie (bo mamy np. mrugnięcie uwagowe, saccadic supression, oscylacyjne teorie wszystkiego itp).
- Wykazanie, że zadanie antysakadowe jest powszechnie poważane jako dobra miara kontroli
- Brakujący mi klej między kontrolą a uwagą
- Argumenty literaturowe za istnieniem trendu i oscylacji (behawioralnych) w varying cue-stimuli interval
- Pointa, że to się klei, że skoro uwaga ma być niestabilna w czasie, to i zadanie je mierzące powinno być niestabilne w czasie i to właśnie pokazuje literatura. (Znów, brak kleju)

Rozdział 2

Zarysowanie problemu, a mianowicie, że chcemy na własne oczy sprawdzić co to się dzieje w tym varying cue-stimuli interval. Tutaj nie wiem na ile warto/należy spoilerować zakończenie.

Chapter III. What our data shows?

To examine the role of CSI in stimulus discrimination, we used the antisaccade task with CSI varied in millisecond steps. On each trial, participants were shown for 250 ms either left or right arrow as a target, and their task was to press the appropriate key. The arrows were randomly displayed on either the left or right side of the screen. The stimulus was accompanied by a red dot briefly flashing on the opposite side of the screen, which should be ignored. The fixation point and the red dot/stimulus presentation were separated by a blank screen shown for CSI ranging from 400 to 900ms. We conducted two experiments, one with lower resolution (less trials per participant) but a larger sample (N=150, CSI sampling frequency 60Hz) and the other with higher resolution but a smaller sample (N=40, CSI sampling frequency 120Hz). Both data sets were analyzed in the same way. For each participant, the mean accuracy was calculated for each CSI timepoint. These mean accuracy values were plotted as a function of increasing CSI, with a single curve created for each person.

Anti-saccade task

The antisaccade task is one of the most popular measures of cognitive control. On each trial, participants were shown for 250 ms either left, right, up or down arrow as a target, and their task was to press the appropriate key. The arrows were randomly displayed on either the left or right side of the screen. The stimulus was accompanied by a red dot briefly flashing on the opposite side of the screen, which should be ignored. The fixation point at the very beginning of a trial, and the red dot/stimulus presentation were separated by a blank screen shown for a ranging time, called the cross-stimuli interval (CSI).

Data preparation

Sekcja 3.1

Dane N=150, niskie próbkowanie CSI 200-1000 ms. Już zebrane i przeanalizowane. Wniosek - jest trend, ale malutki, dużo mniejszy niż w literaturze (i hope so)

Methods. We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Sekcja 3.2

Dane N=40 wysokie próbkowanie, CSI 400-900 ms. Już zebrane i przeanalizowane. Wniosek, brak trendu, zarówno w analizie zbiorczej dla każdej z częstotliwości (to od Tomasza) jak i różnic indywidualnych (kończę robić)

Sekcja 3.3

Dane N=Przyzwoicie_Ale_Nie_Za_Duzo niskie próbkowanie, CSI 500(?)-3000(?)ms Nie zebrane. Wniosek, daj Bóg, że trend znika.

Rozdział 4

Dlaczego nasze wyniki nie pokrywają się z literaturą? Sekcja 4.1 Trend Bo efekt wisiał na punkcie w 200 ms czyli na mrugnięciu uwagowym. Sekcja 4.2 Oscylacje Wnioski i symulacje z artykułu metodologicznego o niepoprawnym preprocessigu. W końcu jest to już, marnie bo marnie, ale napisane.

Konkluzja: Nasze dane pokazują, że cue-stimuli interval nie oscyluje i ma bardzo mały/nie ma efektu trendu.

Rozdział 5

Nasze obserwacje nie zgadzają się z obecnym stanem rzeczy. Co gorsza, twierdzimy że wiemy dlaczego. Nasi biografowie nazwą to zjawisko Kroczek&Chuderski Tension w analogii do Hubble Tension - największego kryzysu współczesnej kosmologii. W tym momencie czytelnik ma już mokre poty i zjadł wszystkie paznokcie. Gdy myśli, że jego nerwy nie mogą być już bardziej napięte to walimy go w łeb obuchem stawiając pytanie, czy w takim razie uwaga/kontrola jest jednak stała w czasie, czy zadanie antysakadowe nie jest dobrą miarą kontroli. Czytelnik mdleje.

Rozdział 6

W oparciu o Roudera stawiamy tezę, że zadanie antysakadowe nie mierzy kontroli i przedstawiamy kolejny eksperyment który temu dowodzi. Opisujemy eksperyment i pokazujemy, że zadanie antysakadowe nie tyle jest marną miarą kontroli, co jest zadaniem na processing speed.

Rozdział 7

Konkluzja pracy, w jakich obszarach (teorie uwagi) nasze wnioski mogą namieszać. Future directions. Tłum wiwatuje w ekstazie. Kurtyna.

References

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