Conference of the Research Group

Handling Visual Distraction

Conference Handbook

DFG Research Group FOR 2293:
Active Perception

CAS
Research
Groups

Munich/ Ammersee, July 22nd-25th, 2022

Introduction

Dear participants,

As the organizers of this conference and the speakers of the research group, we cordially welcome you to conference of the Research Group *Handling Visual Distraction* funded by the Center for Advanced Studies at Ludwig-Maximilian-Universität (CAS^{LMU}). In our view, the conference and the ensuing Munich stays are the culmination of what has been and hopefully will continue to be a very successful large-scale collaboration that is so far unprecedented in our research community.

We have divided the symposium into four *thematic sessions*. Although some thematic structuring was necessary to organize the presentations, the session themes are, of course, closely interrelated, so that issues focused on in the earlier sessions may be highlighted again, from some complementary perspective, in later sessions. Thus, the resulting whole will be more than the parts. There five sessions/themes are:

Session 1 (Friday afternoon/evening): Theories and Models of Visual Search

Session 2 (Saturday morning): Distractor Suppression

Session 3 (Saturday afternoon): Regularities and Broadening the Picture

Session 4 (Sunday, all day): Search Experience/Statistical Learning

Session 5 (Monday morning): Perception, Action, and Working Memory

Each fellow of the CAS group will have 30 min to present their most exciting empirical work and theoretical ideas related to the topic of the research group, followed by a 15-min discussion. Towards the end of each day there will also be a General Discussion that is meant to give us time for wrapping up what we have learned over the day and for considering in more depth issues that cut across and bring together the contents of the individual talks. Saturday evening is reserved for a poster session featuring great contributions from many junior scientists.

We wish to thank all speakers for accepting our invitation and agreeing to contribute to this conference and the research group. Further, we thank the Center for Advanced Studies (CAS^{LMU}) and the DFG Research Group FOR 2293: Active Perception for making all this possible via their generous financial support. Last but not least: we would like to especially thank all those who worked behind the scene to make this conference possible, in particular: Isabella Schopp and Lena Boumann from the CAS^{LMU} and Birgitt Aßfalg, Gabriella Zopscak, and Thomas Geyer from the chair of General and Experimental Psychology at LMU.

We wish you all a productive, intellectually exciting and enjoyable conference.

Hermann Müller & Heinrich Liesefeld

Program Overview

	Friday, 22nd	Saturday, 23rd	Sunday, 24th	Monday, 25th
07.00		Breakfast	Breakfast	Breakfast
09.00		N. Gaspelin	J. Theeuwes	C. Frings
09.45		M. Müller	B.A. Anderson	D. Draschkow
10.45		D. Kerzel	A. Schubö	N. Busch
11.30		N. Carlisle	D. van Moorselaar	J. Golomb
12.15	Lunch	Lunch	Lunch	Lunch
13.30	Welcome (14.00)	S. Boettcher	M. Turatto	Discussion
14.15	J. Wolfe	J.P. Röer	H. Slagter	
15.15	H. Colonius	Discussion	J. Geng	
16.00	H.R. Liesefeld	Poster	A. Leber	
17.00	D. Lamy	Session	Discussion	
17.45	Discussion			
18.30	Dinner	Dinner	Restaurant Dinner	

Program

Friday, July 22nd

11.15	Arrival & Check-in	The ferry from Herrsching leaves at 10.45
12.15	Lunch	

14.00	H.J. Müller	Welcome address
Talk Session 1: Theories and Models of Visual Search		
14.15	J. Wolfe	What is wrong with Guided Search 6.0?
15.00	Afternoon Break	
15.15	H. Colonius	Some observations on modeling (guided) search
16.00	H.R. Liesefeld	Search slopes and search modes: The odyssey, a goal, and new strategies
16.45	Evening Break	
17.00	D. Lamy	Attentional capture and the priority map
17.45	General Discussion	
18.30	Dinner	

Saturday, July 23rd

07.30	Breakfast	

Talk Session 2: Distractor Suppression

09.00	N. Gaspelin	Attentional suppression of highly salient distractors
09.45	M. Müller	Dynamics of attentional allocation to targets and distractors during visual search
10.30	Morning Break	
10.45	D. Kerzel	Does attentional suppression occur at the level of perception or decision-making?
11.30	N. Carlisle	Top-down attentional suppression
12.15	Lunch	

Talk Session 3: Regularities and Broadening the Picture

13.30	S. Boettcher	Distraction during extended dynamic visual search
14.15	J.P. Röer	Stimulus-specific and unspecific effects of handling distraction
15.00	Afternoon Break	
15.15	General Discussion	

Poster Session

16.00	Poster Presentations	incl. snacks
18.30	Dinner	

Sunday, July 24th

07.30	Breakfast	

Talk Session 4: Search Experience/Statistical Learning

09.00	J. Theeuwes	What to expect when you are not expecting it: How implicit regularities drive attentional selection
09.45	B. Anderson	Selection history and the suppression of physically salient stimuli
10.30	Morning Break	
10.45	A. Schubö	Prior selections determine where we attend
11.30	D. van Moorselaar	Learning to search: New approaches to reveal expectation-dependent attentional biases
12.15	Lunch	
13.30	M. Turrato	The role of expectation in habituation to onset distractors
14.15	H. Slagter	Attention and Inhibition in the Predictive Brain
15.00	Afternoon Break	
15.15	J. Geng	Learned distractor suppression prevents sensory readout
16.00	A. Leber	The control of learned distractor suppression
16.45	Evening Break	
17.00	General Discussion	
18.15	(Restaurant) Dinner	for speakers and LMU staff: at Seehaus Riederau; meeting point for bus shuttle: BVS main entrance at 18.15; for everybody else: at the conference venue

Monday, July 16th

07.15	Check-Out & Breakfast	baggage can be deposited at the back of the conference room

Talk Session 5: Perception, Action, and Working Memory

09.00	C. Frings	Action control meets visual search
09.45	D. Draschkow	Handling visual distraction during active visually guided behavior
10.30	Morning Break	
10.45	N. Busch	The role of lateralized alpha oscillations in visual perception, attention, and short-term memory
11.30	J. Golomb	The consequences of spatial distraction for visual feature perception and memory
12.15	Lunch	
13.30	General Discussion	
14.45	Departure	The ferry to Herrsching leaves at 14.55

Additional information

How to get to the venue

[Route 1] Arriving directly from the airport. If you travel by plane, you will arrive at Munich Airport from where you have a direct S-Bahn connection to Herrsching. At the airport, follow the green “S-Bahn” signs (green circle with a white S). Before you enter the S-Bahn platform, please buy a ticket (the relevant ticket is “9-Euro-Ticket” (Juli); price: €9) – you can do this directly opposite to the S-Bahn platform entrance. This ticket does not need to be stamped. The venue is located ca. 80 km southwest of Munich airport; thus, please calculate some additional 2 hours to reach the venue! We recommend you to use public transport (i.e., ‘S-Bahn’ = suburban railway; in particular: S-Bahn No. 8 – the destination is “Herrsching”; alternatively, you can also use S-Bahn No. 1 to “Laim”, where you change the train to S8), which is frequent (departures are every 10 min), inexpensive and convenient to use; transport by taxi would be prohibitively expensive; please note that we are unable to cover the additional expenses of taxi transport. In Herrsching most participants will take the ferry to Holzhausen on Friday morning, 10.45 am.

[Route 2] Taking the S8 to Herrsching. Those of you who already stay in Munich the night before the conference. On Friday morning, please make sure to arrive at Herrsching S-Bahn station in time to reach the ferry at 10.45 am. This would mean that you would have to leave the hotel ca. 08:45. (It is a ca. 1.5h travel from Munich to Herrsching and a 5min walk from Herrsching train station to the ferry). From many places you can take a subway (U-Bahn) No. 3 or 6 to Marienplatz, where you enter S-Bahn No. 8 to reach Herrsching.

[Route 3] Taking the train to Utting. You may also use the train (“Deutsche Bahn”): There is a train connection from Munich Central Railway Station to the town of Utting (the transfer is about 50 minutes; the distance between Utting and the venue is only 2 kilometers – you can walk directly at the lake or take a taxi at your own costs).

Conference dinner (Sunday, 18.30-21.30; CAS fellows / Munich Team)
The conference dinner will be at "Seehaus" at the town of Riederau, which is located approximately 10 km away from the venue. – There will be a joint bus tour to the restaurant. Seehaus is well-known for its original French and Italian meals and scenic location, directly at the Ammersee-shore. The bus tour will start at 18.30 in front of the venue. Note that the conference dinner is intended mainly for CAS fellows / the Munich team, though a limited number of seats may be available for other participants too.

As an alternative to the conference dinner, you may stroll to the well-known „Alte Villa" in Utting (approx. 30-40 min walk) – a traditional Bavarian beer garden located directly at the Ammersee. There is a path/street starting directly at the venue (close to the railway track) towards the village of Utting and the Alte Villa.

Swim in the Ammersee lake
BVS is equipped with its own jetty/bath house, which can be used/entered with your individual room keys. The jetty is located directly on the left-hand side of the conference room. It is a great – and unique – BVS facility and you should thus ultimately consider taking a swim in the Ammersee lake!

Check in / Check out
Check-in is possible from 11.15 on Friday (directly when we plan to arrive with the ferry from Holzhausen). The BVS asks us to check out before the first talk on Monday morning (during the breakfast time) in order to prepare for the next guests. Baggage can be deposited at the back of the conference room after check out.

Talks
Presentations should ideally be in PowerPoint format (4:3 or widescreen; the projector can handle either screen format). A Macbook and a Windows PC will be provided. Please make sure to copy your presentation to the hard drive of the Macbook or Windows PC in the conference room before the start of your session. Of course, you may also use your own computer – in particular, if you use any other presentation software than PowerPoint.

Posters (Saturday, 16.00-18.30)
Poster walls will be arranged on Friday afternoon (around 14.00-15.00). At this time, posters can already be put up. The poster walls are designed for A0 portrait.

Internet/email
Free Wi-Fi is available at the entire venue and the Wi-Fi network name is "BVS-WLAN-GÄSTE" (no password required).

Access to conference venue
Your individual room keys will also allow late, i.e., evening/ night, access to the conference building (main entrance).

Payment (external poster presenters)
When you check out, payment can be made in cash (in Euro) or by credit card. The venue accepts two forms of credit cards: Visa and Master Card.

Talk Abstracts (temporal order)

Session 1: Theories and Models of Visual Search (Friday afternoon/evening)

What is wrong with Guided Search 6.0?

Jeremy Wolfe[1,2]
[1]Harvard Medical School, Boston, MA, US; [2]Brigham & Women's Hospital, Boston, MA, US

Guided Search 6.0 (GS6) was a new shiny model when it came out in 2021 and I am still quite fond of it. However, like all of our models, it is wrong. I will briefly review GS6 and then talk about three (or maybe four) problems. Problem 1) Guidance often seems not to be as good as GS6 says it should be. Part of the problem is we don't really understand even the most uncontroversial of guiding features. 2) GS6 asserts that there is very fast, item by item selection in search but this remains really hard to prove. Alternative accounts, involving processing of 'clumps' of items or regions of the image are also hard to prove. This is the 2022 version of the classic serial/parallel debate. Can we make progress here? 3) There has been quite a bit of work on a quitting rule to end a search. Interestingly, we have ignored the need for an item by item quitting rule. You need to be able to stop analyzing an item, even if you have failed to identify it. Finally, 4) GS6 pointed out that the Functional Visual Field (or Useful Field of View) is not a single, well-defined thing. Unfortunately, the tri-partitite account of the FVF in GS6 is not entirely satisfactory. As other attendees of this meeting will be happy to point out, there are other problems, too, but this will do for one talk. At least, we will not lack to projects to work on going forward.

Some observations on modeling (guided) search

Hans Colonius[1]
[1]Carl von Ossietzky Universität Oldenburg, Germany

Comprehensive computational models, like Guided Search 6.0 (Wolfe, 2021), cover many aspects of visual search and allow for many detailed experimental results including visual distraction phenomena. Simulations of such a model can prove that it is able to produce the observed pattern of experimental results. However, there are certain limitations inherent in the simulation-based formulation for the analysis and fitting of visual search models (e.g., impossibility to systematically search the parameter space). Alternatively, developing a completely formalized quantitative model (like GSDT, Schwarz & Miller, 2016) yields closed-form results for response probability and search time (reaction time) as a function of display size and target presence/absence allowing efficient parameter estimation and goodness-of-fit tests. Yet, such an approach typically comes at the cost of subscribing to specific parametric assumptions (e.g., LBA, diffusion) that cannot be probed separately. Thus,
it seems worthwhile to try a middle ground and (re-)consider possible general tests of priority map building and search modes (parallel/serial, self-terminating/exhaustive and potential hybrid versions) without subscribing to a specific parametric model. We outline the emerging difficulties and some potential avenues.

Search slopes and search modes: The odyssey, a goal, and new strategies

Heinrich R. Liesefeld[1], Anna M. Liesefeld, Talke Michaelsen[1], & Hermann J. Müller[2]
[1]University of Bremen, Germany; [2]Ludwig-Maximilians-Universität München, Germany

A beautiful finding has catapulted research on visual search to the forefront of cognitive sciences where it has since remained for over 40 years: when people look for a single feature (e.g., "red"), the number of objects in the display does not affect the time it takes to find an object possessing that feature. However, when people look for a combination of features (e.g., "red" and "horizontal"), search times increase as a function of the number of objects. This pattern has been accounted for by a stunningly simple model in which all objects are either processed in parallel without any limitation by capacity or noise or via an object-by-object serial search. Many straight-forward predictions from this model have been disproven and apparently simpler models assuming just a single (parallel or serial) search strategy have been proposed. Likely due to the initial focus on parallel vs. serial search, these subsequent models have focused on explaining variation in search slopes. And they were successful, too successful maybe: it appears that any of a dozen mechanisms can easily predict a continuous variation in search slopes and other signature patterns of search data. Thus, we shall argue, traditional search slopes are not suited as a criterion to distinguish search modes and models. An alternative criterion might be whether a salient object causes distraction. As the presence of distraction has been explained by search modes, this reasoning is currently circular. Thus, it appears to be high time to look for an alternative to measuring search slopes. We have started developing this alternative.

Attentional capture and the priority map

Dominique Lamy[1] & Aniruddha Ramgir[1]
[1]Tel Aviv University, Israel

There is a wide consensus around the idea that (1) where attention will be shifted next depends on the combined influence of stimulus salience, observers' goals and selection history on a general priority map and that (2) at any given moment, attention is shifted to the location with the highest priority on that map. In the first part of this talk, I will claim that the rationale that underlies many studies of attentional allocation is inconsistent with the first premise of this framework in two prominent ways. First, many studies draw conclusions about the factors that determine attentional priority by conflating net capture / suppression effects with mechanisms. Second, the notion that certain classes of stimuli automatically capture of attention is still very much alive, yet the fact that this idea necessarily implies that other sources of priority are vetoed is not explicitly entertained. In the second part, I will reconsider the second premise, namely, the hypothesis that attention is shifted to a new location whenever the peak of activation on the priority map changes, which is implicit in the current characterization of priority maps.

Session 2: Distractor Suppression (Saturday morning)

Nicholas Gaspelin[1], Brad T. Stilwell[1], & Howard Egeth[2]
[1]State University of New York at Binghamton, NY, US; [2]Johns Hopkins University, Baltimore, MD, US

A longstanding question has been whether physically salient objects—such as uniquely colored objects—can automatically capture visual attention. As a potential resolution, the signal suppression hypothesis proposes that observers can learn to prevent attentional capture via a proactive inhibitory process. However, research supporting this account has been challenged on the grounds that the singletons that were used had low salience. According to stimulus-driven accounts, proactive suppression is possible, but only of low-salience stimuli, as highly salient stimuli cannot be suppressed. Although computer-based models of salience suggest that the singletons used in earlier work were indeed highly salient, the current study directly addressed this challenge by adapting previous approaches to make the singleton even more salient. Specifically, we increased the set size of search displays, which should increase the salience of the color singletons. Both psychophysical and electrophysiological evidence (the P_D component) indicated that salient items were suppressed and did not capture attention. The results support the signal suppression hypothesis and refute the claim that highly salient color singletons cannot be suppressed.

Dynamics of attentional allocation to targets and distractors during visual search

Matthias M. Müller[1], Norman Forschack[1], Matt Oxner[1], & Christopher Gundlach[1]
[1]University of Leipzig, Germany

We tested a central prediction of the signal suppression hypothesis in visual search (Gaspelin et al., 2015): processing of distractors will be proactively suppressed below the level of nonsingleton distractors (fillers) when foreknowledge of the singleton’s feature (color or shape) exists. A contrasting proposal holds that (salient) distractors capture attention initially, and irrelevant stimuli are excluded later. In two EEG studies, we concurrently measured stimulus-driven steady state visual evoked potentials (SSVEPs) and intrinsic alpha band responses along with event related potentials (ERPs). Although we found a distractor positivity elicited by distractors that is seen as neural signature of proactive distractor suppression, SSVEPs and alpha band responses provided converging evidence against early proactive suppression of highly salient distractors. Results indicate that both, stimulus and goal-driven allocations of attention occur in conjunction with one another. Two EEG control experiments revealed that continuous marking of the locations at which the search display items were presented resulted in a dramatic and unexpected shift in the latency of negative event-related potentials associated with the allocation of attention to search targets.
In a number of letter probe task behavioral studies, we tested an alternative account for the “below baseline suppression” of distractors typically reported in such studies. We propose that the pattern of “below baseline suppression” is actually a consequence of feature-based global facilitation of the target color, given that targets and fillers always share the same color. In line with this interpretation, by manipulating the color of fillers, probe recall “suppression” for singleton distractors was abolished and probe recall for fillers was enhanced as a function of target-filler color similarity.

Does attentional suppression occur at the level of perception or decision-making?

Dirk Kerzel[1]
[1]University of Geneva, Switzerland

Visual attention is often inadvertently captured by salient stimuli. It was suggested that it is possible to prevent attentional capture in some search tasks by suppressing salient stimuli below baseline. As a result, search times decreased on distractor-present compared with distractor-absent trials. Evidence for attentional suppression comes from various tasks and measures. I will mainly focus on evidence from a probe task that was interleaved with the main search task, but I will then go on to discuss evidence from oculomotor suppression and event-related potentials. In the probe task of Gaspelin et al. (2015), letters were shown on the stimuli of the search display and participants had to identify as many letters as possible. Performance was found to be worse for letters shown on the distractor compared to non-salient nontarget stimuli, suggesting that distractor processing was suppressed below baseline. However, it is unclear whether suppression occurred at the level of perception or decision-making because participants may have reported letters on the distractor less frequently than letters on nontargets. This decision-level bias may have degraded performance for letters on distractor compared to nontarget stimuli without changing perception. After replicating the original findings, we conducted two experiments where we avoided response bias by cueing only a single letter for report. We found that the difference between distractor and nontarget stimuli was strongly reduced, suggesting that decision-level processes contribute to attentional suppression. In contrast, the difference between target and nontarget stimuli was unchanged, suggesting that it reflected perceptual-level enhancement of the target stimuli. Further, I will discuss the question whether results from oculomotor capture or event-related potentials are caused by perceptual- or decision-level processes.

Top-down attentional suppression

Nancy B. Carlisle[1]
[1]Lehigh University, Bethlehem, PA, US

While much research has shown the power of learned suppression on distractor processing, the research on top-down control of distractor suppression is more limited. In cued attentional suppression, individuals are presented with a distractor cue prior to each search trial. Because this distractor cue changes across trials, it is maintained in working memory and any effects driven by the distractor must be related to top-down control. In this talk, I will highlight some of the key findings related to cued attentional suppression driven by top-down control. I will draw some broad conclusions about the situations where cued suppression occurs, and the mechanisms underlying the effect drawing from across the literature.

Session 3: Regularities and Broadening the Picture (Saturday afternoon)

Attentional suppression of highly salient distractors
Distraction during extended dynamic visual search

Sage E.P. Boettcher[1], Nir Shalev[1], Gwenllian Williams[1], Anna C. Nobre[1]
[1]University of Oxford, UK

Natural behaviour extends over time. Task relevant targets and irrelevant distractors dynamically move in and out of our visual field. Nevertheless, traditional laboratory tasks remain static. As such, it is unclear how we handle visual distraction during more dynamic extended searches. To this end, we have developed a dynamic visual search task to closer approximate the natural flow of everyday life. Here, we address two important open questions. First, we ask how regularities within the temporal domain may facilitate behaviour in the face of ongoing distraction. Second, during extended behaviour in which participants are tasked with finding multiple targets, we seek to understand the role of 'task-relevant distraction' i.e., other targets. For example, imagine you are searching for two friends at a crowded train station. How does finding the first friend affect your ability to find the second? Does this change if your second friend appears at a predictable moment in time? Results from our dynamic visual search task indicate that 1) participants are better able to find temporally predictable – compared to unpredictable – targets even amongst dynamic distraction and 2) this predictability effect is modulated by the temporal distance from other targets. These effects highlight the importance of time for understanding distraction during natural behaviour.

Stimulus-specific and unspecific effects of handling distraction

Jan Philipp Röer[1]
Witten/Herdecke University[1]

In this talk, I will present some of my work on stimulus-specific and unspecific effects of handling distraction relevant to the two fundamental mechanisms at the heart of the working group, (1) how cognitive control mechanisms can serve to counter interference, and (2) how the cognitive system detects and reacts to regularities and irregularities within the distractor material.

Session 4: Search Experience/Statistical Learning (Sunday, all day)

What to expect when you are not expecting it: How implicit regularities drive attentional selection

Jan Theeuwes[1,2,3]
[1]Vrije Universiteit, Amsterdam, The Netherlands, [2]Institute Brain and Behavior Amsterdam (*i*BBA), The Netherlands, [3]William James Center for Research, ISPA, Lisbon, Portugal

Lingering biases of attentional selection affect the deployment of attention above and beyond top-down and bottom-up control. In this talk I will present an overview of recent studies investigating how statistical learning regarding the distractor determines attentional control. In all these experiments we used the classic additional singleton task in which participants searched for a salient shape singleton while ignoring a color distractor singleton. The distractor singleton was presented more often in one location than in all other locations. Even though observers were not aware of the statistical regularities, we show that the location of the distractor was suppressed proactively relative to all other locations. Moreover, we show that this learning to suppress is highly flexible and adaptive, can be tuned to those moments in time when the distractor is expected and is not affected by working memory load. Critically, explicit awareness of the regularities has no effect on learning. We claim that spatial statistical learning operates by continuously adjusting weights within an assumed “spatial priority map”, which at any moment in time dynamically controls the deployment of covert (and overt) attention. When a location contained relevant information in the past, that location is up-regulated, whereas a location is down-regulated when it has a higher probability of containing distracting information. In this view, selection simply follows the priority landscape that arises after combining a variety of signals, such as current goals and bottom-up saliency, within which priority weights are induced by previous selection episodes.

Selection history and the suppression of physically salient stimuli

Brian Anderson[1]
[1]Texas A&M University, College Station, TX, US

Although physically salient stimuli have elevated attentional priority, their attentional priority can be effectively downweighted as a result of selection history. In this talk, I will discuss some recent work from my lab probing the mechanisms by which such learning-dependent changes in attentional priority are realized and how they relate to other mechanisms of experience-dependent attentional control. First, I will present evidence that both proactive and reactive mechanisms of attentional control downweight the priority of physically salient distractors when they appear in locations where distractors are frequently encountered. Next, I will present evidence showing that such statistically learned distractor suppression and the value-based modulation of attentional priority combine additively, consistent with independent contributions to priority. I will then discuss evidence that reward learning can contribute to signal suppression: it is possible to implicitly learn to suppress physically salient reward cues in order to maximize gains. I will close by highlighting a case of undesirable signal suppression in the real world and the preliminary results from a collaboration with a construction science lab aimed at rapidly curbing such suppression via a manipulation of selection history that leverages virtual reality training.

Prior selections determine where we attend

Anna Schubö[1]
[1]Philipps University Marburg, Germany

Selective attention is the mechanism that helps us to decide which objects to attend and which to ignore. Attentional control depends on the salience of objects, on the observer's goals and intentions, and their prior experience gained in similar situations. But not only targets, also distractors determine where we attend, and how efficiently a distractor competes for attention depends on the value associated with it. Recent work has shown that observers can learn to ignore distractors when experiencing some form of spatial or featural regularly in selection. It thus seems likely that successful distractor ignoring is achieved by tuning the internal task representation to upcoming target and distractor features; mechanisms that relate to selection history and also to top-down control. In our recent work using behavioural and EEG measures, we contrasted selection history and higher-level control processes to examine how they contribute to target and distractor processing in selection. Our findings show that preparatory top-down control can have a substantial impact on a distractor's salience signal, but cannot overrule a distractor value that has been acquired in a series of earlier selections. Predictability can help to counteract such a distractor bias, but neither prevent nor eliminate it.

Learning to search: New approaches to reveal expectation-dependent attentional biases

Dirk van Moorselaar[1]
[1]Vrije Universiteit Amsterdam, The Netherlands

Much insight has been gained into how selective attention may filter information processing at the neural level, by directly boosting relevant information (target facilitation), and/or by suppressing irrelevant information (distractor inhibition). Yet, there is still debate as to whether target facilitation and distractor inhibition are simply two sides of the same coin or whether they are controlled by distinct neural mechanisms. Recent work indicates that distractor suppression only emerges when information about the distractor can be derived directly from experience, suggesting that suppression of distracting information is in particular expectation dependent. This raises the question as to how attention and expectation interact to bias information processing. I will discuss recent findings from behavioral and EEG studies that examined how expectations about upcoming target or distractor locations and/or features influence facilitatory and inhibitory effects of attention on visual information processing and representation using ERPs, multivariate decoding analyses, and inverted encoding models. Specifically, I will focus on the question whether, and if so when, learned attentional biases are evident in anticipatory neural tuning or whether they only become apparent after stimulus presentation. Also, I will present work demonstrating how the latent landscape of the attentional priority map, which we suggest is modulated by statistical learning across visuals searches, may be revealed via perturbation of the visual system with visual noise.

The role of expectation in habituation to onset distractors

Massimo Turatto[1]
[1]University of Trento, Italy

The distraction caused by irrelevant peripheral onsets is subject to habituation. According to the Sokolov (1960, 1963) model of habituation, the waning of the orienting reflex, of which the covert orienting of attention is a key component, arises when the input (potentially distracting) stimulus matches the “expected” one, which is anticipated on the basis of the statistics of past events. By contrast, attention is summoned by surprising or unexpected stimuli. Hence, expectation is hypothesized to play a key role in learning to ignore irrelevant onsets. Data will be presented showing that expectation can be generated, for example, on the basis of the onset probability at different locations, regardless of onsets numerosity. However, the data also indicate that habituation to onsets can be controlled by contextual information via associative learning mechanisms. Overall, the presented findings support the view according to which the attenuation of distraction in the case of onset stimuli finds a straightforward explanation in a habituation mechanism like that proposed by Sokolov, which relies on cognitive factors like expectation, emerging from statistical learning or generated by contextual information.

Attention and inhibition in the predictive brain

Heleen Slagter[1]
[1]Vrije Universiteit Amsterdam, The Netherlands

Over the past decade or so, it has become clear that our brains continuously predict what sensory signals are likely informative for goal-directed action based on past experience and statistical regularities in the environment, and hence, that learning is a much more pervasive feature of attention than is commonly assumed. In this talk, I will focus on the question of how the brain learns to ignore or suppress that what is not goal-relevant or distracting from the task at hand. I will discuss two possibilities: learning to anticipate what is distracting results in preparatory suppression versus foreknowledge about what is distracting enhances attention for what is then potentially relevant. To this end, I will present findings from behavioral and EEG studies from our group. These findings do not settle the debate, but identify important avenues for future research.

Learned distractor suppression prevents sensory readout

Joy J. Geng[1]
[1]University of California Davis, CA, US

Efficient execution of daily-life activities requires the ability to ignore task-irrelevant information. Recent work has suggested that distractors are suppressed most effectively when they recur and become expected over time. In this talk, I will describe experiments in which we explore how this type of learned suppression operates during visual search and its effect on subsequent memory. Our results suggest that suppression occurs rapidly in behavior and this is likely supported by changes in visual processing of simple features, preventing sensory readout to parietal and frontal attentional control regions. Together the results suggest that learned suppression operates in visual cortex, perhaps due to local mechanisms such as habituation that attenuate repeated but task-irrelevant information.

The control of learned distractor suppression

Andrew B. Leber[1]
[1]The Ohio State University, Columbus, OH, US

The notion that individuals can suppress salient, irrelevant visual information has attracted a great deal of recent research, as well as some controversy. Much of this work has focused on suppression emerging via incidental learning (i.e., without awareness or intent). While substantial advances have been made, several key outstanding questions remain pertaining to the mechanisms underlying learned suppression. I probe two such questions. 1) Is learned suppression governed by a low-level selection history mechanism, resulting from the accumulation of repeated encounters of an irrelevant feature or location; or, is suppression more flexibly adjusted from moment to moment based upon the relevant behavioral/environmental context? I present results favoring the latter alternative. 2) Is learned suppression implemented proactively or reactively? Despite a wealth of previous reports claiming the former, I present evidence favoring the latter. I will discuss the theoretical and methodological implications of both of these findings, and I will share suggestions for charting the course of future research on this interesting cognitive capacity.

Session 5: Perception, Action, and Working Memory (Monday morning)

Action control meets visual search

Christian Frings[1]
[1]Trier University, Germany

Human action always comprises aspects of selecting environmental information and programming, selecting, and executing the motor programs that fit to the agent's goals given the particular environment. In the Psychology literature, the 'environmental selection' part has been predominantly analyzed in the attention or visual search literature while the responding or acting part has been analyzed in the action control literature. Both literatures more or less ignore each other. I am going to argue that both approaches have the same goal albeit starting from a different end. Both approaches use partially the same mechanisms (with different labels) to explain behavior. In my talk I focus on intertrial effects in Visual Search as the procedural structure of the experiments is used in both research areas. Given the topic of this research group, I focus on the role of distractors in such intertrial priming studies. First data looking at intertrial priming effects from an action control perspective will be presented as well as data making the argument that response information of distractors already influences the visual processing. The main gist of my talk is that both research strands will profit from being connected with each other.

Handling visual distraction during active visually guided behavior

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Protecting information in working memory from potential distraction is essential for efficiently bridging between perception and subsequent behavior. During natural behavior, we are likely to encounter many forms of distraction while we hold an object in mind. Visual objects (distractors) encountered during maintenance make up the most obvious, and well-studied type of distraction (e.g., seeing the cream cheese as we search for the butter). However, during natural tasks interference can also arise from visual translations and the computation required for changing object coordinates in an immersive space (e.g., keeping track of where to put the pins while rotating through the environment to construct a wardrobe according to a manual). In a virtual reality experiment, we show that these different types of interference (visual distractors vs visual translation) during the period between encoding information and using it, enact differential effects on several hallmark sub-components of complex visually guided behaviors. Most notably, interference from distractors decreased reliance on memory, whereas interference from visual translations increased reliance on memory. Our results showcase the impressive flexibility of adaptive behavior when handling different forms of interference.

The role of lateralized alpha oscillations in visual perception, attention, and short-term memory

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The alpha-rhythm is the most prominent brain rhythm in the human EEG with a frequency of approximately 10 Hz. States of strong alpha power are thought to reflect a state of physiological inhibition, e.g. as indicated by reduced firing rates. This can occur either spontaneously or in response to a task requiring selective inhibition of task-irrelevant or distracting information, corresponding to the spotlight of attention. I will present a series of experiments investigating the role of alpha band lateralization, i.e. the relative distribution of inhibition and excitability between the two cortical hemispheres. Specifically, we found that spontaneous alpha lateralization biases perception such that the subjective contrast of Gabor patches is amplified in the more excitable hemisphere. Furthermore, we found that alpha lateralization can be evoked with exogenous cues. Interestingly, alpha lateralization reflected only attentional capture at the cued location, but not the subsequent inhibition of return at non-cued locations. Finally, we studied alpha lateralization and contralateral delay activity in visual short-term memory. When the eyes move during memory maintenance, do these lateralized signals primarily reflect the memoranda's retinotopic location before the saccade, or their spatiotopic location? We found that the contralateral delay activity (CDA) reflects memory representations coded in retinotopic coordinates, while alpha lateralization reflected a memory-unspecific screen center bias. Overall, these studies confirm the link between alpha lateralization and excitability, but also show that the direction of lateralization can be decoupled from the locus of attention.

The consequences of spatial distraction for visual feature perception and memory

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Visual attention, perception, and memory are delicately intertwined. Spatial attention not only facilitates visual processing and enhances visual perception; attention is also theorized to serve as the “glue” for object feature-binding and to gate visual working memory encoding. How are these processes affected when the focus of spatial attention is disrupted during involuntary attentional capture? Decades of research have characterized how and when spatial attention is redirected to (and disengaged from) task-irrelevant distractors, but we have less understanding of how salient distractors could impinge on other aspects of perception and/or memory. In this talk I'll describe a recent series of studies from our lab revealing widespread consequences of spatial distraction, including findings that attentional capture can alter feature perception, disrupt non-spatial category-tuned filters in ventral visual cortex, and cause incidental features to intrude into visual working memory. Thus, when spatial attention is captured by a salient distractor, the consequences can ripple across these other processes, carrying important implications for our understanding of handling distraction.

Poster Abstracts (alphabetical order)

Bayesian updating models of inter-trial effects in visual search: a factorial model comparison

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Salient but task-irrelevant distractors interfere less with visual search when they appear in a display region where distractors have appeared more frequently in the past. In this study we tested two different theories of such statistical distractor-location learning. It could reflect the (re-)distribution of a global, limited attentional 'inhibition resource'. Accordingly, changing the frequency of distractor appearance in one display region should also affect the magnitude of interference generated by distractors in a different region. Alternatively, distractor-location learning may reflect a local response to distractors occurring at a particular location. In this case, the local distractor frequency in one display region should not affect distractor interference in a different region. To decide between these alternatives, we conducted three experiments in which participants searched for an orientation-defined target while ignoring a more salient orientation distractor that occurred more often in one vs. another display region. Experiment 1 varied the ratio of distractors appearing in the frequent vs. rare regions, with a fixed global distractor frequency. The results revealed the probability cueing effect to increase with increasing probability ratio. In Experiments 2 and 3, one ('test') region was assigned the same local distractor frequency as in one of the conditions of Experiment 1, but a different frequency in the other region – dissociating local from global distractor frequency. Together, the three experiments showed that distractor interference in the test region was not significantly influenced by the frequency in the other region, consistent with purely local learning.

Crossmodal learning of target-context associations

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Contextual cueing is the effect frequently reported of visual search becoming faster for visual targets presented among previously encountered visual distractor layouts relative to random ones. An important question is how general contextual cueing actually is in real-life scenarios. In particular, two important, and interrelated, questions arise on this type of learning: 1) does contextual cueing operate across sensory modalities? 2) is this type of learning supported by modality-dependent or -independent long-term memory (LTM) mechanisms? To answer these questions, we developed a fully-factorial cross-modal search task, in which the invariant predictive context and the target came from different (visual, tactile) modalities. Crucially, the spatial configuration of the target-context was fixed for the half of the trials and random for the other half. Using a combination of behavioral and lateralized ERP markers of pre-attentive (N1, N2) and focal-attentional processing (CDA) obtained from parieto-occipital and somatosensory electrodes in a visual or a tactile odd-one-out search task, we found that when participants searched for a visual feature singleton, with repeated (and nonrepeated) distractor configurations presented either within the same (visual) or a different (tactile) modality, both uni- and crossmodal context cues benefitted the same, visual processing stages related to the selection and subsequent analysis of the search target. In contrast, when the searched-for target was tactile, both somatosensory and visual cortical regions contributed to more efficient processing of the tactile singleton in repeated stimulus arrays. Together, these findings demonstrate that 1) contextual cueing of search is supported by cross-sensory target-context associations; and 2) these LTM mechanisms operate in separate co-existing reference frames, though in different weighting ratios, which is set by the modality that contains the predictive, i.e., learnable information.

Examining the effect of saliency on EEG markers of attention allocation and maintenance in a visual-working-memory task

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While limitations on visual working memory (VWM) are well established, less is known about what it takes for stimuli to enter this precious space. Using dense displays adapted from the visual-search literature, it was recently demonstrated that stimulus saliency strongly influences VWM performance (Constant & Liesefeld, 2021, https://doi.org/10/gjk9jh). In the present work, we performed two EEG experiments (16 participants each) with similar tasks adapted for extracting lateralized event-related potentials to gain more insight into the cognitive mechanisms by which saliency affects VWM performance. Participants memorized the color of 3 tilted target bars presented in a dense array of colored vertical non-target bars for later recall. Saliency was manipulated via target tilt (12°, 28°, or 45°). Memory displays of Experiment 1 contained three targets, each with a different saliency level and including conditions with two targets presented on the midline (in order to isolate activity induced by a single lateralized target). Some interesting exploratory results were that (when in competition with more salient targets) the least salient target produced very little lateralized activity, maybe because it was not attended nor stored when competing against more salient targets. We also found indication that the most salient target evoked a contralateral positivity (reminiscent of a Pd) after its N2pc. This could indicate that it needs to be attentionally suppressed in order to attend the next salient target. In Experiment 2, to extract cleaner measures of saliency, all targets of a given memory display shared the same tilt and were presented in the same visual hemifield (in order to maximize lateralized activity). The N2pc was larger for displays with targets of higher saliency, potentially indicating enhanced attentional processing. We also observed a significant effect of saliency on the evoked lateralized theta ITPC at the electrodes and time range of the N2pc. The CDA increased only marginally with saliency, potentially indicating relatively saliency-independent utilization of VWM storage.

EEG evidence for enhanced attentional performance during low-intensity exercise

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Researching attentional control within real-world contexts has become substantially more feasible and thus frequent over the past decade. However, relatively little is known regarding how attentional processes are influenced during common naturalistic behaviours such as aerobic exercise, which could potentially modulate the availability and/or utilisation of neurometabolic resources. Here, we employed an event-related potential (ERP) approach to determine whether various intensities of aerobic exercise might influence the concurrent performance of attentional control mechanisms. Participants performed an additional-singleton visual search task across three levels of aerobic activity while seated on a stationary bicycle: at rest, during low-intensity exercise, and during moderate-intensity exercise. In addition to behavioural measures, attentional performance was assessed via lateralised ERPs referencing target selection (N2pc) and distractor suppression (P_D) mechanisms. Behaviourally, engaging in exercise was found to speed response times overall. However, low-intensity exercise demonstrated unique electrophysiological effects, both eliminating distractor-induced delays in attentional allocation as expressed by the N2pc and giving rise to an unanticipated distractor-elicited Ppc. These findings demonstrate workload-specific and object-selective influences of aerobic exercise on attentional processing, providing insights not only for approaching attentional control within real-world contexts, but also for understanding how attentional resources are utilised overall.

Predictable temporal structures help protect internal representations from external interference

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In everyday life, maintaining goal-relevant information in working memory rarely occurs without concurrent exposure to distracting sensory input or intervening tasks. Yet, factors contributing to the resistance of internal representations to external interference remain poorly understood. In two experiments, we investigated whether predictable temporal structures reduce the negative impact of interference on subsequent memory performance. In experiment 1, we manipulated the temporal predictability of interference during the retention period of a working-memory task. By including both distractors that could be suppressed and interrupters that had to be responded to, we addressed whether potential advantages of temporal expectations result purely from distractor suppression (which would only benefit the distractor condition) or might also be due to memory shielding (which would benefit both the distractor and interrupter conditions). In line with the latter, we show that temporal expectations protect working memory similarly from both types of interfering events. In experiment 2, we took the inverse approach and manipulated temporal expectations regarding when memory was probed, without modifying the timing of the interference (here, only interrupters). We demonstrate that temporal expectations about when to utilise internal representations significantly benefit memory performance, even when an intervening task is completed in the interim. Overall, we show that predictable temporal structures help safeguard internal representations from external interference.

Search for a fixed target or a varying target: Does the precision of the target template influence distractor location learning?

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The extent of attentional capture in visual search tasks is modulated by the precision of the target template: distractor cost is lower when the target is a fixed feature target (e.g., a diamond), allowing observers to use a precise, feature-specific target template compared to when the target is a shape singleton target (e.g., either a diamond or a circle). It has also been shown that distractor cost can be reduced via distractor location learning. Whether the precision of the target template influences distractor location learning is not yet clear. We assumed that with a feature-specific target template, observers can down-weight the distractor, thereby reducing the need for distractor location learning. We implemented the additional singleton search task with a spatial bias of the distractor location. In one version, participants searched for a fixed target, in the other for a varying target; distractor features were constant between tasks. Results showed reduced RT cost when the distractor appeared at its high-probability location, but no interaction effect between tasks. To further quantify distractor location learning, i.e. emergence and persistence of learning, and the distribution of spatial suppression across the visual field, we implemented hierarchical Bayesian models. Modeling estimates revealed no differences between tasks in the learning curves or the spatial gradient of suppression, but slower overall task performance when observers searched for a shape singleton target. These findings provide further evidence that location learning fosters distractor suppression. Target template precision does not seem to influence distractor location learning, but overall task performance.

Contextual cueing of singleton distractors affects attentional capture

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It is well established that contextual cueing facilitates the detection of a target among irrelevant items during visual search. However, whether contextual cuing can also reduce attentional capture by a highly salient distractor is less clear. In this study, we examined whether cueing of singleton distractor location by context reduces its ability to capture attention.
Adapting the contextual cueing paradigm, we tested this effect of context on capture of early attention by singleton distractors. In an online experiment, participants were tasked with performing two intermixed tasks: search for a singleton shape among a field of distractor elements (⅔ of trials), and a letter probe task (⅓ of trials) to probe the focus of early attention. In half of search trials and all probe trials, a singleton colour distractor was present. Half the trials consisted of configurations repeated throughout the experiment. Critically, for one group of participants (n = 72), the repeating search displays were associated with a consistent target location, while for another group (n = 72), they were associated with the location of the singleton distractor. This allowed us to disentangle the effects of target and singleton predictability on early orienting of attention.
Our findings show that, while target predictability does not modulate attentional capture by the singleton, predictable singleton distractors capture less early attention after learning. This confirms that attentional context is a crucial factor in determining the ability of a salient distractor to capture attention.

How placing instructions influence visual search and action planning in a foraging task

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When searching for multiple objects, as e.g., in visual foraging, humans usually interact with objects, which also requires planning of the appropriate movement, such as reach, grasp, and object handling. Although visual foraging and action planning are closely tied in the real world, their interaction in natural environments has hardly been investigated. To start closing this gap, we asked participants to pick and place LEGO bricks of one color in a non-exhaustive real-world foraging task. Specific instructions (collect, sort, pile) differed between trials, leading to distinct precision requirements, and hence differences in task difficulty. We expect longer movement time and lower maximum movement speed with more complex task instructions. We further expect participants to use certain strategies to minimize efforts and energy-expenditure, e.g., by picking targets in the central picking area. The poster will present the experimental set-up together with first results.

The attentional earlid: Visual pop-out search is robust to auditory distraction when sound is irrelevant

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Distraction by salient-but-irrelevant visual stimuli (distractors) is well established for visual pop-out search. The generalizability of this classic effect to auditory distractors is examined in the present study. Participants reported whether the target (a 12° - tilted bar in a dense array of vertical bars, presented in half of the trials) was present or absent in each trial. In Experiment 1, half of the trials were accompanied by an auditory stimulus. Contrary to the expectations, there was a significant *decrease* in reaction times (RTs), without any significant change in accuracy when the auditory stimulus was present, indicating that the distractor might have acted as an alerting signal. However, an integrated performance measure that is relatively insensitive to speed-accuracy trade-offs – the Balance Integration Score (BIS; Liesefeld et al., 2015; Liesefeld & Janczyk, 2018, 2022), revealed no effect of the auditory distractor on visual-search performance. Experiment 2 confirmed that the employed task is sensitive to distractor interference by replacing the auditory distractor with a salient visual distractor (color singleton); indeed, all dependent measures showed a significant decrease in visual-search performance. Experiment 3 eliminated the potential alerting signal by presenting an auditory stimulus in all trials, while an additional auditory stimulus – the distractor - occurred in 50% of the trials. This auditory distractor did not produce any effect on RTs, accuracies, or BIS. Experiments 4 and 5 replicated the absence of interference using an auditory oddball stimulus (which is particularly attention-grabbing) presented in 25% of the trials, either simultaneously (Experiment 4) or 300-ms prior (Experiment 5) to the visual display. Finally, in Experiment 6, the auditory modality was made relevant – while still maintaining irrelevance for the search task –, by introducing an additional task of counting a second sound which was presented only in a few trials. The results revealed a significant interference effect on the performance of the visual-search task when the auditory distractor was present. Together, our results indicate that the performance of a visual pop-out search task is not affected by an auditory distractor when the auditory modality is completely irrelevant. However, the interference effect surfaces when the auditory modality is made relevant globally, while still keeping it irrelevant for the search task.

Improving the measurement of object processing speed in visual search

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The processing speed of visually perceptible objects is important in many scientific fields. Therefore, providing adequate methods to measure object processing speed is of high relevance. The slopes of the functions relating reaction times (RTs) in a visual-search task to the size of the search set (*search slopes*) have been used for this purpose, but are, unfortunately, not a valid measure of object processing speed. For example, it seems clear by now that many influences beyond mere processing time per object influence such search slopes (see Liesefeld & Müller, 2020) and that the relationship between the number of objects and RTs might actually be non-linear (Lleras et al., 2020). The present work aims at developing an entirely new approach: Instead of analyzing search times as a function of set size, we attempt to analyze search times as a function of the position of the target within displays of constant set size that are searched in a specific order. If this relationship is linear, the search slopes measured with our approach should provide a valid measure of processing time per item; all remaining, but time-consuming processes would affect only the intercept of the function. Rather than presenting a final validated design here, we report on the process to highlight the potential pitfalls of our novel approach and outline validated strategies to avoid them. An emerging finding of some relevance that was only discoverable with our new task design is the unexpected degree to which search strategies are idiosyncratic and difficult to get under experimental control.

Learned distractor locations can reduce feature interference

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We are often bombarded with salient stimuli that can capture our attention and distract us from our current goals. Decades of research has shown the robust detrimental impacts of salient distractors on search performance and, of late, in leading to altered feature perception. These feature errors can be quite extreme, and thus, undesirable. In search tasks, salient distractors can be suppressed if they appear more frequently in one location, and this learned spatial suppression can lead to reductions in the cost of distraction as measured by reaction time slowing. Can learned spatial suppression also protect against visual feature errors? To investigate this question, participants briefly viewed four colored squares on every trial, with the target item indicated by a bold, white frame. Participants subsequently reported the target color on a color wheel. On two-thirds of trials, a salient distractor (four white dots) appeared around one of the nontarget squares. We created a predictable distractor location by presenting the salient distractor in one location on 62.5% of distractor-present trials. Participants' responses were fit to a probabilistic mixture model estimating performance parameters and compared across conditions. Our results showed that general performance (guessing rates and response precision) was improved when the salient distractor appeared in a likely location relative to elsewhere. Critically, large feature swap errors (probability of misreporting the color at the salient distractor's location) were significantly reduced when the distractor appeared in a likely location, suggesting overall that suppression of a salient distractor helps protect the processing of target features.

Long-term (statistically learned) and short-term (inter-trial based) distractor location suppression arise at different, pre- and post-selective processing stages

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A salient distractor in the search display interferes less with the detecting and responding to a less salient target when it occurs at a location where distractors are likely vs. unlikely to occur. Additionally, on distractor-absent trials, search has been reported to be slower when the target appears at the location of a distractor on the preceding trial vs. a non-distractor (distractor-target location coincident vs. non-coincident). While these two reaction-time (RT) effects may reflect the operation of pro-active (statistically learned) and, respectively, retro-active (cross-trial) distractor location suppression, it is not clear at what stages of processing – between pre-attentive attentional-priority computation and post-selective item processing – these effects actually arise. Here, we adopted a Theeuwes-type (1992) additional-singleton search paradigm and examined both lateralized event-related potentials (L-ERPs) and lateralized alpha power (8-12 Hz) of the EEG to shed further light on the temporal dynamics of these two effects. Behaviorally, we replicated both effects: RTs were faster (i.e., distractor interference relative to the distractor-absent baseline was reduced) when distractors occurred at the likely vs. an unlikely location; and, on trials without a distractor, RTs were slower when the target appeared at the previous distractor vs. a non-distractor location. The statistical target-location effect was reflected in the early N1pc and N2pc components (without any effect on the lateralized alpha power during the pre-stimulus period), indicating that the acquired target-location suppression operates (largely) at an early processing stage. In contrast, the cross-trial distractor-target location coincidence effect was reflected in the SPCN component, suggesting that attentional processing of the selected item (in visual working memory) – to establish that it actually is the searched-for target and then decide upon the requisite response – is more demanding when the target occurs at a previous distractor (vs. a non-distractor) location, consistent with a starting-point shift in the decision process of whether the selected item is a distractor vs. a target (cf. Allenmark et al, 2020 and Sauter et al., 2021).

Predictability modulates distractor-response binding effects, but modulation depends on spatial information

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When we respond to a stimulus, stimulus and response features are integrated into a short-lived memory trace, called an event file. If some or all features comprised in an event file repeat in a later episode the previous event file is retrieved and can induce costs and benefits for the current behavior. These costs and benefits are together referred to as S-R binding effects. These effects can not only emerge for relevant stimuli but also irrelevant distractor stimuli. Previously it was shown that if certain characteristics of an episode are predictable these effects are entirely absent. These findings follow a growing body of evidence in the visual search literature that also demonstrates effects of predictability. However, the visual search literature shows that their predictability effects work independently of stimulus/feature identity but are proactively implemented based on spatial information. We here merge the findings of predictability in visual search and S-R binding effect literature. We show that the influence of predictability on S-R binding effects also relies on spatial information. This further demonstrates the tight link between these areas of research and implies that the role of attention for S-R binding effects has been previously underestimated.

Introducing dimension repetitions and changes reveals binding effects in localization performance

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Many action control theories assume that upon responding to a stimulus, stimulus features (e.g., color, shape, etc.) and the accompanying response are coupled into a short-episodic memory trace, that is, an event file. Repeating any component retrieves the previous event file, affecting ongoing performance. Although robust in discrimination tasks, the resulting so-called binding effects are absent in localization performance. In such tasks, a location change benefit emerges, known as inhibition of return (IOR), typically unmodulated by repeating or changing a non-spatial feature inherent to the target. The latter is usually varied on a feature level (e.g., repeating or changing colors). Based on the dimension weighting account from visual search, we hypothesized that the lack of binding effects in localization performance is due to a lack of systematically varying feature dimensions of non-spatial features. Participants gave localization responses to targets popping-out in search displays in the left or right hemifield. The target popped-out by repeating its dimension with or without the individual feature, or it changed its dimension. Binding between the response and individual feature was completely absent. However, there was a strong binding pattern between response and feature dimension. IOR was observed throughout. By merging ideas from action control, attentional orienting, and visual search, the results show that it is possible for localization performance to be affected by non-spatial information as proposed by action control theories: Repeating or changing feature dimensions is what spurs on integration and retrieval in localization tasks.

Contextual cueing: display-specific guidance vs. one-for-all optimization of scan-patterns in visual search

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In a hard, T-vs.-L's search task, when the target is encountered repeatedly at a fixed location relative to a stable spatial distractor arrangement ('context'), detecting the target becomes more efficient over time compared to non-repeated contexts, in terms of search RTs and the requisite number of eye movements. This 'contextual-cueing' (CC) effect has been attributed to the acquisition of display-specific long-term memories, which, when activated by the item arrangement on a given trial, guide search to the target location by raising its attentional priority. The present study was designed to explore an alternative, 'procedural-optimization' account of CC, according to which contextual facilitation arises from the acquisition of 'generic', yet idiosyncratic oculomotor scanning strategies that are optimized with respect to the whole set of repeated (and non-repeated) displays, replacing the notion of display-specific search guidance. To test these alternative accounts, we first replicated established measures of the CC, including the reduced number of fixations in scanning repeated displays. In addition, we developed and analyzed novel oculomotor-scanpath measures (at the level of both individual participants and display arrangements), notably, a measure of scanpath homogeneity. The results revealed display repetitions to improve the display-unspecific production of sequential eye movements (from the very first saccade onwards) - consistent with the alternative account. We propose that scanpath homogeneity increases with learning more for repeated than for non-repeated displays, because the former, by virtue of being repeated, have greater weight in shaping the generic scanpath than (non-repeated) displays that are encountered only once in the experiment.

Do robots distract us as much as humans?

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In a dynamic and rich environment, attention is a vital mechanism for solving problems. As artificial agents increasingly become part of our lives, the question of if they distract us as much as humans and to what extent remains unanswered. To answer these questions, we conducted four experiments. Participants were engaged in a central letter detection task and in half of the trials one distractor agent (robot, android, or human) appeared at the periphery. We also examined modulations based on prior knowledge, task difficulty, and mode of presentation of the distractors. Our experiments revealed that task difficulty modulates attentional capture leading to reduced performance more in easy tasks when distractors are dynamic, but not static. Overall, robot and android agents showed to be similar to human agent when assessing attentional capture. The android agent, however, captured a higher degree of attention than the human agent when we informed participants about the identities of the dynamic agents they would be interacting with. In the absence of prior information, no such effect was observed. In addition, robot and android agents captured attention differently depending on the task difficulty when prior information was absent. Robot and android agents captured more attention in the easy task, however, distraction by the human agents did not reveal a similar modulation. Our findings suggest that human appearance and motion capture attention regardless of source availability modulated by task difficulty. The processing of complex stimuli (dynamic) and unfamiliar stimuli (robot and android) is modulated by the availability of the source.

Asymmetric learning of dynamic spatial regularities in visual search: facilitation of anticipated target locations, no suppression of predictable distractor locations

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Statistical regularities in the placement of targets and salient distractors within the search display can be learned and used to optimize attentional guidance. Whether statistical learning also extends to dynamic regularities governing the placement of targets and distractors on successive trials has been less investigated. Here, we applied the same dynamic cross-trial regularity (one-step shift of the critical item in clock-/counterclockwise direction) either to the target or a distractor, and additionally varied whether the distractor was defined in a different (color) or the same dimension (shape) as the target. We found robust learning of the predicted target location: processing of the target at this (vs. a random) location was facilitated. But we found no evidence of proactive suppression of the predictable distractor location. Facilitation of the anticipated target location was associated with explicit awareness of the dynamic regularity, whereas participants showed no awareness of the distractor regularity. We propose that this asymmetry arises because, owing to the target's central role in the task set, its location is explicitly encoded in working memory, enabling the learning of dynamic regularities. In contrast, the distractor is not explicitly encoded; so, statistical learning of distractor locations is limited to statical regularities.

Global context guides early attentional selection independent of item identity in visual search: evidence from lateralized event-related potentials

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Stable spatial arrangement of items can efficiently guide attentional selection and facilitate visual search over time, a phenomenon known as contextual cuing. Specifically, participants show speeded performance when repeated relative to novel configuration of search items are presented over the course of the initial learning phase of an experiment. On the other hand, updating of already formed long-term context memories in the relocation is rigid and often requires prolonged training. In more detail, participants made more errors and showed no context benefits when the target was permanently relocated to a new position within an already learned spatial arrangement of items. Previous EEG work showed that the lack of context-related benefit is associated with an early (~ 150 ms after stimulus onset) attentional misguidance, where attention in to-be-relearned search displays is attracted to previously learned, but no longer relevant target locations. In the current work, we explored whether global context regularities can guide and mis-guide early attentional selection in the absence of individual item identities. For this purpose, we used lateralized event-related electroencephalogram (EEG) potentials and presented a group of participants (N = 16) with repeated and non-repeated displays that were preceded by a spatial mask for 500 ms. In more detail, the mask contained placeholders that marked the position of items that would be presented half a second later, but could not reveal the identity of the search items (target vs. distractors). The behavioral results revealed reliable contextual cuing during the initial learning phase. Importantly, we found an early attentional guidance ERP component some 150 ms after mask onset (N1pc ERP component), i.e., when only a global configuration of search items was presented to participants. Furthermore, when the target was relocated to the opposite hemifield in the relocation phase, contextual cuing was effectively abolished, and the N1pc was reversed in polarity already during the mask phase, which is indicative of persistent misguidance of attention to the original target location. These findings suggest that, once learned, repeated layouts trigger attentional-priority signals from memory that proactively interfere with contextual relearning after target relocation, even in the absence of stimulus identities.