

RGC Ref. No.: UGC/FDS23/H03/19 <p>(please insert ref. above)</p>
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**RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR**

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

Submission Deadlines:

1. Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.
2. Completion report: within **12** months of the approved project completion date.

Part A: The Project and Investigator(s)

1. Project Title

Extending the dual-route account for visual perception and localization

2. Investigator(s) and Academic Department(s) / Unit(s) Involved

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Lee, Terence Chak-Pui / Division Leader & Senior Lecturer	Division of Social Sciences / College of International Education / HKBU SCE
Previous Principal Investigator	Chan, Ka-Ho / Lecturer (Dr. Chan has been resigned from HKBU SCE since 2022 August)	Division of Social Sciences / College of International Education / HKBU SCE
Co-Investigator(s)	Chan, Wing-lui / Assistant Professor (Dr. Chan has been resigned from HKSJU since 2022 June)	Department of Counselling and Psychology / HKSJU

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval (must be quoted)
Project Start Date	1 January 2020	N/A	N/A
Project Completion Date	31 December 2022	N/A	N/A
Duration (in month)	36	N/A	N/A
Deadline for Submission of Completion Report	31 December 2023	N/A	N/A

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.

N/A

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. Design and validate experimental paradigms for teasing apart guidance and post-selective stage effects
2. Identify whether dimension-repetition effects in visual search stems from a search guidance or feature identification process
3. Determine whether the search guidance process is top-down modifiable
4. Examine whether spatial and non-spatial processing in visual search co-occur in the same time

5.2 Revised objectives

N/A

5.3 Realisation of the objectives

In this research project, we conducted 16 visual search experiments, including planned and new experiments. We expanded our research scope based on suggestions from reviewers in our initial application. Due to the pandemic, we had to re-implement our experiments online, which slightly slowed down our progress.

Objective 1: Design and validate experimental paradigms for teasing apart guidance and post-selective stage effects

- We designed and programmed our online experiments based on our plan outlined in the application. These tests were conducted in terms of both accuracy and response time (RT), and a perceptual threshold measurement of exposure time using a staircase paradigm.
- We validated our experimental designs by successfully replicating the standard inter-trial and capture effects in visual search. Validity effects of spatial cueing are within expectations.

Objective 2: Identify whether dimension-repetition effects in visual search stems from a search guidance or feature identification process

- We conducted 6 experiments to identify the origins of dimension-repetition effects in visual search. We tested the effects of repeating the target-defining and response-defining dimensions, which correspond to the search guidance and feature identification processes, respectively.
- Experiments 1.1 - 1.2: We measured RTs while simple and compound tasks were mixed across trials. Results showed that repeating either the target- or response-defining dimension led to inter-trial effects, consistent with previous findings, but only repeating the response-defining dimension produced a benefit when tasks were changed across trials.
- Experiments 1.3-1.6: Using a staircase approach, we measured the exposure duration required to achieve a threshold accuracy level. This method helped us to ensure our findings reflected perceptual and not decisional constraints.

Objective 3: Determine whether the search guidance process is top-down modulable

- We tested the attentional capture effect produced by an across-dimension distractor on compound search performance. In addition, we used a non-informative spatial precue to study the robustness of across-dimension attentional capture.
- Experiments 2.1-2.2: We measured the cue validity and attentional capture effect in RTs. Results showed significant cue validity and attentional capture effects with both types of precue. The attentional capture effect was not reduced by a valid cue in compound search.
- Experiment 2.3: Using a staircase approach, we measured the exposure durations needed for a threshold accuracy level. We found significant cue validity and attentional capture effects, confirming the results in Experiments 2.1-2.2.

Objective 4: Examine whether spatial and non-spatial processing in visual search co-occur at the same time

- We tested across-dimension attentional capture and spatial precue of attention in simple search.
- Experiments 3.1-3.2: We measured the cue validity and attentional capture effect in RTs. Result showed both effects to be significant. When the spatial cue was valid, the attentional capture effect was significantly reduced.
- Experiment 3.3: Using a staircase approach, we measured the exposure durations needed for a threshold accuracy level. We only found a significant cue validity effect using this approach. The attentional capture effect was not evident.

Extended investigations

- We ran four other experiments on studying continuous visual search. Experiment 4.1 tested for a target-rate effect in terms of hit RTs and target miss rates. Experiments 4.2-4.3 tested for relative target-rate effects across monitoring for two target features among distractors of changing colours and orientations. Experiment 4.4 tested the influence of general vigilance on continuous visual search in terms of the above measurements.

5.4 Summary of objectives addressed to date

Objectives <i>(as per 5.1/5.2 above)</i>	Addressed <i>(please tick)</i>	Percentage Achieved <i>(please estimate)</i>
1. Design and validate experimental paradigms for teasing apart guidance and post-selective stage effects	✓	100%
2. Identify whether dimension-repetition effects in visual search stem from a search guidance or feature identification process	✓	100%
3. Determine whether the search guidance process is top-down modifiable	✓	100%
4. Examine whether spatial and non-spatial processing in visual search co-occur at the same time	✓	100%

6. Research Outcome

(Please see next page)

6.1 Major findings and research outcome

In this research, we evaluated the revised dual-route account using new research paradigms. Our findings offer more coherent explanations to existing findings on inter-trial dimension repetition benefits and across-dimension attentional capture effects on simple and compound tasks. In the below, we outline the implications of our findings around the three main notions of the account.

1. *A common device for preattentive and post-selective feature perception*

We proposed to align the two-streams hypothesis (Goodale & Milner, 1992; Ungerleider & Mishkin, 1982) with the revised dual-route account. This alignment means that both preattentive and post-selective feature perception share the same neural underpinnings (the what-pathway). Our experimental result showed that repeating the response-defining dimensions across simple and compound searches produced an inter-trial benefit, and this benefit was found in both RTs and the exposure durations of a threshold accuracy level. This result strongly supports a common device for the preattentive feature perception in simple search and the post-selective feature perception for identifying responses in compound search.

Most other visual search accounts attribute the inter-trial effects in simple search to the repetition of its target-defining dimensions (e.g., Müller & Krummenacher, 2006; Töllner et al., 2009; Zehetleitner, Proulx, & Müller, 2009), explaining the effect in terms of dimension-weighting of the search guidance process. Contrary to this, our results showed no transfer of dimensional repetition effect of the target-defining dimension across simple and compound searches.

2. *Top-down configurability of each route*

The dual-route account explains dimension-repetition benefits and the lack of across-dimension attentional capture in simple tasks as the what-pathway's ability to select a feature dimension. In contrast, the lack of dimension-repetition benefits and presence of across-dimension attentional capture in compound search tasks reflect the where-pathway's inability to select features.

To determine whether the search guidance process is top-down modulable, we tested the attentional capture effect produced by an across-dimension distractor on compound search performance. Our results showed that across-dimension attentional capture persisted in compound search even when attention was preallocated, and it persisted in both RT and threshold exposure duration estimations. In contrast, the across-dimensional attentional capture observed in simple search RTs does not persist when attention was preallocated or when we used threshold exposure duration measurements. This result suggests that the influence of across-dimension information on search guidance was outside of top-down control, as opposed to the feature perception process.

3. *Guidance-identification parallelism*

The dual-route account suggests that simple tasks are supported by non-spatial feature perception that is dimensionally selective and would not expect an attentional capture effect. While previous experiments showed that attentional capture does not generally occur in simple search (Chan & Hayward, 2009, 2014), there are circumstances where attentional capture can occur in simple search (e.g., Zehetleitner et al., 2011). The revised dual-route account proposes that the feature perception pathway and search guidance pathway generally operate at the same time. For instance, the searcher could have unnecessarily relied on the search guidance process in a simple task. The current result confirmed this hypothesis by showing that attentional capture observed in simple search RTs was not replicated in threshold exposure duration measurements. This concurs with the dual-route account that simple search responses can, on one hand, be influenced by spatial processing, but at the same time, the search performance was critically supported by non-spatial processing.

Extended investigation

We studied continuous visual search, which required continuous monitoring for a target feature among dynamically changing features. This task displayed a target-rate effect similar to the low-prevalence effect in regular visual search, in which hit RTs were slower and miss rates were higher when targets were rare. Target-rate effects were also observed for relative frequencies across two target features. These research findings are published in Research Output 1 (Chan & Chan, 2022).

6.2 Potential for further development of the research and the proposed course of action (*Maximum half a page*)

The current research provided further evidence to support the three main notions of the revised dual-route account. Here are several directions in which the current research can be extended:

- Accumulate more evidence for the simple-compound search difference

The original dual-route account aimed to explain the difference between simple and compound search dimension-specific performance. As research progressed over the years, focus has been put on borderline cases where simple searches can show dimension-agnostic performance, or compound searches can show dimension-specific performance, under very specific experimental conditions. However, a larger mass of research results comparing the dimension-specific performance of both search types under the same condition, across a wider variety of stimulus settings, would be critical to establish the basic observation in the first place. It is this basic observation that highlights the importance of the dual-route account.

- Electrophysiological research

The revised dual-route account has important implications for perceptual and attentional neural responses when the perceptual dimensions repeat during simple and compound searches. While previous ERP studies on this topic showed similar characteristics in both search types in terms of attentional components (such as N2pc), this is not incompatible with the dual-route account because of its guidance-identification parallelism principle. Therefore, we propose that more evidence, or a review of previous evidence, on perceptual ERP components (such as P1) in the realm of dimension-repetition effects on simple and compound searches is critical to comparing the revised dual-route account with other one-route accounts.

- Perceptual threshold studies

Experimental results coming from adaptive methods helped us to clarify previous ambiguity on the origin of behavioral effects in visual search. We propose that by systematically extending the current method to a larger variety of test conditions, such as across features of different complexity, task-setting history, practice duration, and different stimulus sequence during a trial, would help clarify many unsettled questions on the temporal sequence and informational dependency between different perceptual and attentional processes.

7. Layman's Summary

(*Describe in layman's language the nature, significance and value of the research project, in no more than 200 words*)

This research project aims to understand the human perception and attentional system by studying the visual search task. Previous research on visual search has established that our brains first analyze all perceptual features in front of us, direct our attention to potentially important locations, and then focus on a visual target and examine it. While most previous research has conceived the above processes as a one-way sequence, this assumption did not consider the neural divergence of attention localization and object recognition as informed by brain research. Also, there was an insufficiency for this assumption to explain certain discrepancies between two types of visual search tasks. Therefore, we previously proposed the dual-route account for visual search.

In this research project, we furthered this dual-route account by aligning the visual search processing stages with the “what” and “where” neural pathways, advancing its claims on dimension specificity of each pathway, and gathering further evidence for these notions. Our findings supported the account. This result leads to important theoretical improvement that clarifies and sharpens our understanding of how the interplay between our perceptual and attentional mechanisms leads to the complex and diverse perceptual behavior that we exhibit in our everyday lives.

Part C: Research Output**8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project**

(Please attach a copy of the publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) (denote the corresponding author with an asterisk*)	Title and Journal / Book (with the volume, pages and other necessary publishing details specified)	Submitted to RGC (indicate the year ending of the relevant progress report)	Attached to this Report (Yes or No)	Acknowledged the Support of RGC (Yes or No)	Accessible from the Institutional Repository (Yes or No)
Year of Publication	Year of Acceptance (For paper accepted but not yet published)	Under Review	Under Preparation (optional)						
2022	2022			Chan, L. K. H.*, Chan W. W. L.	Target-rate effect in continuous visual search	2023	Yes	Yes	No

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

Month / Year / Place	Title	Conference Name	Submitted to RGC (indicate the year ending of the relevant progress report)	Attached to this Report (Yes or No)	Acknowledged the Support of RGC (Yes or No)	Accessible from the Institutional Repository (Yes or No)
2022	Target-rate effects in continuous visual search	VSS 2022 (The 22 nd Annual Meeting of the Vision Sciences Society)	2023	Yes	Yes	No

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

Nil.

11. Student(s) Trained*(Please attach a copy of the title page of the thesis)*

Name	Degree Registered for	Date of Registration	Date of Thesis Submission / Graduation
Nil.	N/A	N/A	N/A

12. Other Impact*(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)*

Nil.

13. Statistics on Research Outputs

	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
No. of outputs arising directly from this research project	1	1	0	0	Type	No.
					N/A	N/A

14. Public Access Of Completion Report*(Please specify the information, if any, that cannot be provided for public access and give the reasons.)*

Information that Cannot Be Provided for Public Access	Reasons
Nil.	N/A