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Dear Editor,

Bayesian multi-level modelling for predicting single and double feature visual search

We would be grateful if you could consider the above manuscript for publication in *Cortex* as a Registered Report.

Visual search, where participants are asked to find a target within a cluttered scene, has long been a popular topic of study in cognitive psychology, and several models have been developed that are able to generate testable predictions about how different types of distractors and targets affect search efficiency. However, in the main, these have been relatively descriptive models. We believe that the use and development of quantitative, mathematical models is highly important for advancing the field: they allow us to make testable predictions and enable us to consider the limitations and assumptions of our theories with greater clarity. Thus, in the current work, we focus on the recently proposed Target Contrast Signal (TCS) theory, a rare example of a model that attempts to quantitatively predict search slopes during visual search.
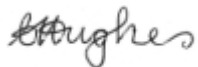
We develop an improved version of the TCS model by extending it to a Bayesian multi-level framework and demonstrate that moving to a shifted-lognormal distribution for reaction times leads to a better the model fit. We also show that the previous datasets used to test the model are not sufficient to distinguish between the various contrast contribution models that have been hypothesized to operate in the TCS model. In the current manuscript, we therefore propose a replication study to a) attempt to replicate the key original findings and b) test some small modifications to help distinguish between theories. We think that the value of carrying out this replication is high: whether we can replicate the original effects is important, but perhaps more critically, our work will help to develop a new theory in visual search. By making our data and code open source, we also hope to encourage other scientists to start testing the model on their own datasets and questions.

We have the necessary support to carry out the proposed experiment: it will be carried out online, and we have funding available to pay the participants. Ethical approval has been obtained (University of Aberdeen, approval number PEC/4677/20201/2).

I confirm that the article has not been submitted elsewhere and that all authors approve of its submission. All authors agree to share the raw data, digital study materials and analysis code. Following Stage 1 in principle acceptance, we will publicly register our proposal on the Open Science Framework until submission of the Stage 2 manuscript. If we later withdraw our paper, we agree to Cortex publishing a short summary of the pre-registered study.

Thank you very much in advance for considering our paper.

Yours sincerely,

Anna Hughes