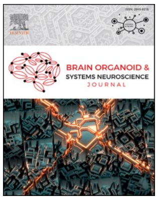
Brain Organoid and Systems Neuroscience Journal 3 (2025) 1–7

Contents lists available at ScienceDirect

Brain Organoid and Systems Neuroscience Journal

journal homepage: www.sciencedirect.com/journal/bosn



Research articles

Cross-cultural differences in attention: An investigation through computational modelling

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ARTICLE INFO

Keywords:
Visual attention
Computational modelling
Culture
SSoTS model
Saliency

ABSTRACT

Background: Behavioural research has shown that cultural membership can shape visual perception and attentional processes. In picture perception, members of collectivist cultures are more likely to attend the whole of the perceptual field than an individual salient item. Members of individualist cultures tend to attend the most salient object in the visual field. Understanding the brain processes that underlie these differences in visual attention is very important, as attentional processes can have significant impact on learning, navigation, communication and more. This study examines the perception of saliency among collectivist and individualist cultural groups using a computational modelling approach that is based on spiking neurons, the binding spiking Search over Time and Space (b-sSoTS) model. We simulated visual search for a salient target among distracters. We successfully simulated cross-cultural differences in early visual processes by altering the coupling parameter and varying the strength of connections between representations in the model. These findings indicate that the one of the potential causes of cross-cultural differences in visual perception can be the differences in encoding the mechanisms between individualist and collectivist cultural groups This study marks the first step investigating these processes by extending the behavioural research finding with computational modelling.

1. IntroductionWestern participants' tendency to focus on local information

Human attentional processes have been extensively studied (Mavritsaki et al., 2011a; Watson and Humphreys, 1997; Wolfe, 2020; Treisman and Gelade, 1980) due to their critical role in daily activities like eating, driving, surfing the web, watching television, writing, and reading. Our visual field is inundated with overwhelming information that compete for awareness and control of action. Consequently attentional processes are essential for efficiently selecting the most relevant information from our visual field to focus on (Mavritsaki et al., 2011a; Watson and Humphreys, 1997; Treisman and Gelade, 1980; Wolfe and Horowitz, 2017; Slagter et al., 2018). This selection process is crucial for optimizing our interactions with the environment and ensuring that we respond appropriately to stimuli. Although there is a vast amount of literature investigating attention, there is limited work focusing on understanding the differences in attentional processes across cultures (Ueda et al., 2018). Human behaviour and cognition have neurobiological underpinnings that are influenced by both experience and environment and cultural factors can significantly influence cognitive processes (Ueda et al., 2018; Chua et al., 2022). Prolonged exposure to specific cultural elements can significantly shape cognitive, behavioural, and perceptual systems (Chang, 2017; Liu et al., 2017; Park and Huang, 2010; Yu et al., 2021). Much of the existing literature is conducted in Western countries, thus overlooking the variability that might arise due to cultural backgrounds. This oversight can lead to narrow understanding of attentional mechanisms.

Individualism and collectivism are key constructs in cultural psychology that are commonly used to explain and predict the cultural differences found in behavioural and cognitive studies (Chua et al., 2022; Kitayama and Uskul, 2011; Oyserman et al., 2002). Individualist oriented cultures are those of Western Europe, North America, and Australia, while collectivism tends to prevail mostly in Asian cultures (Triandis, 1988; Hofstede, 2001). In individualist cultures, people often

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https://doi.org/10.1016/j.bosn.2025.01.001
Received 2 September 2024; Received in revised form 11 December 2024; Accepted 17 January 2025

prioritize personal goals and desires over those of the group, valuing individuality and uniqueness as virtues (Triandis, 1988). Conversely, in collectivist cultures, individuals typically define themselves in relation to their groups, prioritizing collective goals and values over personal ambitions (Rienties and Tempelaar, 2013). To account for cross-cultural differences in behaviour, cognition and other psychological processes, Markus and Kitayama (Markus and Kitayama, 1991) introduced the concept of independent and interdependent self-construal. People holding high levels of an independent self-construal tend to align with individualism, whereas individuals holding an interdependent self-construal tend to align with the cultural norm of collectivism. Independent individuals also have a greater tendency to focus on objects and people within scenes and are less sensitive to the context (Masuda and Nisbett, 2001), while interdependent individuals are more attuned to contextual information (Nisbett et al., 2001a; Kitayama et al., 2003a).

Behavioural research suggests that cultural membership can shape visual perception and attentional processes (Ueda et al., 2018; Chua et al., 2022; Amer et al., 2017; Gutchess and Rajaram, 2023; Lufi and Pan, 2016; Masuda et al., 2016). This can be seen in the way members of collectivist cultures engage with visual stimuli, as they tend to focus on the entire perceptual field and the relationship between the focal point and background rather than isolating a single, salient item. In contrast, members from individualist cultures tend to prioritize attention on the most prominent item in the visual field (Yu et al., 2021; Nisbett et al., 2001a; Ueda et al., 2018; Nisbett and Masuda, 2007). For example, when American and Japanese participants were asked to describe briefly presented pictures, American descriptions were focused on the salient focal object whereas Japanese descriptions focused on the picture background (Nisbett and Masuda, 2007). This tendency was also reflected in a change blindness task (Boduroglu et al., 2009), and in a visual perceptual learning task. Western participants' tendency to focus on local information hindered their ability to learn to differentiate gloabal forms compared to Eastern participants (Chua et al., 2022). It is therefore clear that there are differences in visual processing between Western and Eastern participants. However, the specific stage of processing at which these differences occur is not known.

Research on visual perception across cultures, summarised above, has consistently used tasks where a salient item (target) is presented among other objects (distractors). Measures of attention have included tracking saccadic eye movement, the time it takes to identify the target and the number of successful trials/correct responses (Nisbett et al., 2001a; Ueda et al., 2018; Kitayama and Murata, 2003). More recent work by Ueda et al (Ueda et al., 2018) using a visual search experiment repeated this pattern with abstract shapes and replicated the finding of different attentional patterns between North American and Japanese individuals. Specifically, they found that, as in previous visual search literature, North Americans were quicker to find a long line amongst short lines than a short line amongst long lines. Japanese participants, on the other hand, did not show this search asymmetry. This meant that Japanese participants were slower, taking longer per item, in some difficult searches, compared to North Americans. These differences in search asymmetry patterns between cultural groups extend beyond general processing strategies, such as analytic and holist systems, or basic discriminability (Ueda et al., 2018; Kitayama and Murata, 2003). The effects generalise across various tasks, including those based on letters, line tilt and line length. They proposed that cultural differences must be present even at relatively early stages of visual processing. This is consistent with studies showing differences between cultural groups in early evoked potentials (ERPs) as early as 200 ms (Kitayama and Murata, 2003). Therefore, further research is needed to identify the possible underlying determinants of cultural differences in early processing.

To gain a complete understanding of the role of studied processes (Kriegeskorte and Douglas, 2018; Muthukrishna and Schaller, 2020; Wilson and Collins, 2019) and expand our understanding of the underlying biological mechanisms behind cross-cultural visual differences, we will apply computational modelling to cross-cultural research. While computational modelling has been used in cross-cultural psychology (Muthukrishna and Schaller, 2020; Cioffi-Revilla, 2011; Goldstone and Janssen, 2005; Veissière et al., 2020), the focus has primarily been on simulating cultural groups using agent-based modelling. More recently, Gutchess and colleagues (Gutchess et al., 2021) employed drift diffusion modelling to understand the differences between Turkish people and Americans in their decision making and attention processes. However, to fully understand the cross-cultural differences in tasks such as visual search, above, we need a computational model that can model early visual processing at a sufficient level of detail. The spiking search over time and space model (sSoTS) (Mavritsaki et al., 2011a, 2007a; Mavritsaki and Humphreys, 2016a) is a computational model of visual attention that can simulate the spatial and temporal dynamics of visual processing while also incorporating biologically plausible activation functions.

The study presented employs an innovative cultural neuroscientific design by exploiting a computational approach to investigate the patterns of the salience activation mechanism. We are using a culture-as-situated-cognition approach and computational neuroscience to simulate - and further investigate - the cultural effects upon human visual perception (Oyserman et al., 2002; Ueda et al., 2018). Previous research has not focused on fully understanding the differences in visual attentional processes, as these are often studied in conjunction with other cognitive processes. Existing research results are consistent and indicate that there are differences between cultural groups even in the stages of visual processing (Ueda et al., 2018; Nisbett et al., 2001b). The mechanism of these differences can be explored using sSoTS. This model has previously simulated a range of visual search experiments and has been extensively used to understand the underlying processes (Mavritsaki et al., 2011a; Mavritsaki and Humphreys, 2016a; Mavritsaki et al., 2007b, 2010a).

The aim of this paper is to use the spiking Search over Time and Space computational model (Mavritsaki et al., 2011a, 2007a; Mavritsaki and Humphreys, 2016a) to explore the possible mechanisms underpinning cultural differences on visual perception. Although behavioural has identified significant cross-cultural differences in visual perception (Nisbett et al., 2001a; Kitayama et al., 2003a; Ueda et al., 2018), the exact attention processes are not known. Specifically sSoTS model allows us not only to investigate the changes in perceived items' strength that could simulate the cross-cultural differences but also to focus on early visual processing and investigate if the variations in the visual items' strength alone can produce similar results to previous studies and to predict changes to other measures like reaction times, accuracy and efficiency of the search.

2. Method

The approach presented here uses the sSoTS model. For previous uses of this model to simulate visual cognition please see the following references (Mavritsaki et al., 2011a; Mavritsaki and Humphreys, 2016a; Mavritsaki et al., 2011b, 2010b). For the present work, we are using the latest version of sSoTS, which is the binding spiking Search over Time and Space (b-sSoTS) model that, in addition to previous mechanisms, incorporate a binding mechanism (Mavritsaki and Humphreys, 2016b). The model is illustrated in Fig. 1 and described in more detail below.

Previous work by Ueda and colleagues (Ueda et al., 2018) on geometric shapes demonstrated differences in visual search asymmetry between North Americans and Japanese individuals. In their study, feedback was provided to the participant after each trial, this feedback continuously updated influenced the participants' responses, which makes modelling the underlying attentional biases more complex. Despite this limitation, their work remains one of the closest examples in current research on visual attention. Easterners had higher reaction time in the easier visual search task compared the Westerners, consistent with the early findings of Nisbett and colleagues (Nisbett et al., 2001b) in a picture perception task. Thus, the general finding that we simulate is

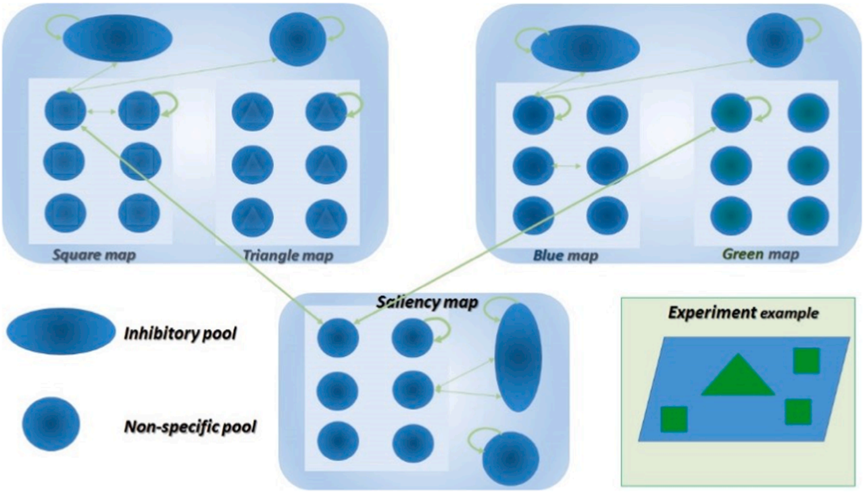

Fig. 1. Fig. 1 presents the b-sSoTS model used to simulate the visual search experiment shown in the right-hand corner. The model simulates an easy visual search task, where the target shares one characteristic with the distractor and there is only one set of distractors. For instance, as illustrated, a green triangle among green squares. The model's architecture consists of three primary layers: two feature dimension layers, shape (square map and triangle map) and one colour map (blue colour map and green colour map), and one saliency map layer that receives input and feeds back information to corresponding positions in the previous two maps. Each layer maintains a ration of 20 % inhibitory to 80 % excitatory neurons. Within the feature dimension layers, feature maps encode specific shape and colour characteristics of items in the visual field. Neurons in pools representing visual field positions are reciprocally connected to non-specific and inhibitory pools. Neurons within each feature map are characterised by loose connection with neurons in other feature maps pools, while maintaining strong coupling with neurons in their own pool. Each position in the feature map corresponds directly to a position in the Saliency map. The connectivity pattern in the Saliency layer mirrors that of the feature map layer (for more information please see 1).

that in a simple or easier visual search experiment, Easterners tend to have higher reaction times that Westerners.

2.1. Simulated experiment

The visual search task simulated here is similar to Ueda et al. (2018). Participants are asked to identify a target among distractors. Performance is measured in terms of the time that it takes for participants to identify the target and accuracy (number of correct trials). Participants are asked to complete several trials, each with different number of items. In the 'easy search' condition, participants are asked to identify a target among a single type of distractors. We call it 'easy search' because as the number of items presented on the screen increases, the time that it takes for typical participants either remains the same or slightly different. This easier search condition is where previous literature has shown cultural differences. As in previous work (Ueda et al., 2018), we simulate search using shapes to represent presentation of culturally neutral stimuli.

The simulations presented here are simulating differences in cross cultural perception using an existing model of visual search (b-sSoTs) (Mavritsaki and Humphreys, 2016b). The model in this current work simulates human performance with distracters in 2, 3, 4 and 6 positions of the visual field. By increasing the number of distracter positions, we can simulate the changes in response time found in experiments as the number of distracters increases. This is quantified by the slope of the line relating the number of distracters to response times (RTs), termed search efficiency. An example of the experiment is presented in the right-hand corner of Fig. 1. Participants must identify the target item amongst non-target distracting items. The number of distracter items varies, and participant reaction times and accuracy are recorded. When participants can efficiently discount the distracters, their performance is faster. Efficient performance is shown smaller increases in reaction time with more distracters, i.e. flatter slopes.

To simulate previous work (Kitayama et al., 2003a; Ueda et al., 2018; Nisbett et al., 2001b), we are using a highly salient target (large green triangle) that is clearly discriminable from the distractors (or background), which are items green squares. Cross-cultural difference research has shown that in similar experiments (for example a big fish presented in front of small background information, Masuda and Nisbett, 2001), participants of individualist cultural background attend to the target quicker than those from collectivist backgrounds. Additionally, participants of collectivist backgrounds tend to look at the background information first, while those from individualist background look at the salient object first. In Fig. 1 we present the network organisation.

2.2. sSoTS model

sSoTS model is a model for visual attention that uses integrate and fire neurons as described in Brunel and Wang (2001) and Deco and Rolls' (2005b) work. The computational model follows the Eqs. (1) and (2) that give us the sub-threshold membrane potential of the neuron.

$$C_m \frac{dV(t)}{dt} = -g_m(V(t) - V_L) - I_{syn}(t) + I_{AHP} \tag{1}$$

$$I_{syn}(t) = I_{AMPA,ext}(t) + I_{AMPA,rec}(t) + I_{NMDA,rec}(t) + I_{GABA}(t) \tag{2}$$

where C_m is the membrane capacitance and g_m is the membrane leak conductance (different values are given for excitatory and inhibitory neurons for both C_m and g_m). V_L is the resting potential, I_{syn} is the synaptic current, I_{AHP} is the current term for the frequency adaptation mechanism, $I_{AMPA,ext}$ is the AMPA external current, $I_{AMPA,rec}$ is the AMPA recurrent current, $I_{NMDA,rec}$ is the NMDA recurrent current and I_{GABA} is the GABA current. More details on the neuronal properties of the model and the parameters used can be found in Mavritsaki and Humphreys (2016b).

The system contains both inhibitory neurons, simulated as interneurons, and excitatory neurons, simulated as pyramidal cells (Mavritsaki et al., 2011a). The model maintains a 20:80 ratio of interneurons to pyramidal cells, matching the ration found in the brain (Mavritsaki et al., 2011a). The neurons receive excitatory input from simulated AMPA and NMDA currents and inhibitory input from simulated GABA current. The neuronal group is connected to 800 external neurons with AMPA like connections. These external neurons simulate input about the external world (for example the position and characteristics of an object presented on the visual field). In addition to inhibitory and excitatory currents, the model includes a frequency adaptation current I_{AHP}, which is crucial for simulating temporal aspects of visual search, as previously demonstrated (Mavritsaki et al., 2011a). Further details for the model can be found in Mavritsaki and colleagues (Mavritsaki et al., 2011b; Mavritsaki and Humphreys, 2016c).

The structure of the network in the model is based on the theories of Treisman and Gelade (1980) and follows the organisation used in work by Deco et al. (2005). The network is separated in 5 maps, and the maps are organised in 3 layers, presented in Fig. 1. There are two layers to simulate the shape/letter and colour dimensions of the stimuli present and a third layer to simulate the Location/Saliency map that links all the input from the dimension layers to Location Map and gives us the location that is more attended. Each dimension layer is comprised by two feature maps (that encode the features of the studies dimension, for example for shape dimension, the feature map is square shape or triangle shape), an inhibitory pool and an excitatory pool that is not linked to any of the studied processes. Each feature map encodes six positions on the visual field, with each position represented by strongly coupled neuronal pools. In each map, the neurons of different positions are loosely connected while the neurons that represent the same position are strongly connected. The neuronal coupling strength correlates with the perceived intensity of the visual field item.

By incorporating Poisson noise, the model can be run for multiple trials, effectively simulating the variability observed in human performance (Deco and Rolls, 2005a). Groups of 20 trials has previously been identified to be enough to simulate performance of one participant (Deco and Rolls, 2005a, 2005b), therefore, 300 trials were simulated in this model to evaluate the reaction times and success rates of 15 participants.

2.3. *Simulation of cross-cultural differences*

In the original model, which primarily simulates visual attention data from participants with individualist backgrounds (Mavritsaki and Humphreys, 2016b), all pools corresponding to occupied positions in the visual field receive a standard frequency input of 150 Hz (e.g. positions 1,2,3 and 4 in green, square and triangle maps). The salient item is simulated by additional increase in frequency in the maps encoding the target's characteristics, termed "top-down" in previous work (Mavritsaki and Humphreys, 2016b). As mentioned earlier, competition occurs within each layer and in the saliency layer, which integrates activations from corresponding position in the feature maps. In the individualist version, positions receiving both top-down and basic input activation compete more effectively, particularly due to strong pool coupling that amplifies the input. However, reducing this coupling decreases the target pool's advantage, potentially simulating the observed differences in early processing between collectivist and individualist groups (please also see more detailed description of the model in the following section).

In our current work, we simulate differences between individualist and collectivist groups by modifying the *wplus* parameter, which controls the coupling strength of the pool of neurons that encode each position in the visual field (48, also see Fig. 1). We start from the point that early visual processes might be affected by cultural differences (Ueda et al., 2018; Kitayama and Murata, 2003) and this is represented by each individual item having a stronger, individual representation. Increasing *wplus* strengthens individual item representations in the visual field; while decreasing it reduces their perceptual strength. For the cross-cultural simulations, we consider the *wplus* parameter as being analogous to *perceived saliency*, and it is the key parameter that determines the encoding strength of the stimuli presented on a specific location. We ask whether the collectivists group has reduced coupling (*wplus*), therefore de-prioritising individual items presented on the visual field. We present results for five different levels of reducing the *wplus* parameter 6 %, 8 %, 10 %, 12 % and 14 %. For the analysis of the results, we follow the same method presented in Mavritsaki and colleagues' (Mavritsaki et al., 2011b).

3. Results

sSoTS successfully simulated the easy visual search task, with average slope 19.96 ms/item, matching the slope found behavioural studies (Watson and Humphreys, 1997).

To investigate whether changing the simulated perceived saliency, we varied the wplus parameter (see above). The changes in the simulated response times for the different levels of reduction of the *wplus* parameter are presented in Fig. 2A. There was a significant overall effect for display size and level of *wplus* $F(3,15)=4.254$, $p < 0.001$. *Response times were increased significantly as the* display size increased $F(3,15)=37.269$, $p < 0.001$ and as the *wplus* level was increased $F(3,15)=2261.005$, $p < 0.001$. The highest number of items display was selected to plot the reaction time differences in Fig. 2B.

Simulated accuracy was calculated for the different levels of reduction of *wplus* and different display sizes. The results are presented in Fig. 3A. There was a significant overall effect for display size and level of *wplus* $F(3,15)=78.919$, $p < 0.001$. Accuracy increased significantly as the display size was increased $F(3,15)=272.544$, $p < 0.001$ and the *wplus* level was increased $F(3,15)=65860.699$, $p < 0.001$. The highest number of displayed items was selected to plot the accuracy differences in Fig. 3B. The accuracy for the 12 % and 14 % reduction in the *wplus* parameter is below chance, the accuracy of *wplus* reduction of 14 % accuracy is 10 % allowing us to assume that this is the level of reduction that allow us to simulate the collectivist group.

The slopes for the different levels of *wplus* reduction are plotted in Fig. 4. We can see that as the *wplus* parameter is decreased the efficiency of the search is decreased. Please note that we did not include the slope for a14 % reduction due to the very low success rate (accuracy). The slopes for the different levels of *wplus* reduction were significantly different from the baseline slope; for 6 % reduction $t(28)= 3.215$, $p = 0.003$; for 8 % reduction $t(28)= 5.785$, $p < 0.001$; for 10 % reduction $t(28)= 4.165$, $p < 0.001$; and for 12 % reduction $t(28)= 4.925$, $p < 0.001$.

4. Discussion

Varying the encoding strength, in the b-sSoTS model (Mavritsaki and Humphreys, 2016b), of items in a visual search task display effectively simulated the cross-cultural differences found in previous behavioural studies (Ueda et al., 2018; Nisbett et al., 2001b; Kitayama et al., 2003b). This makes predictions as to the underlying mechanisms of cultural differences in visual attention. As the *wplus* parameter was reduced in a simulated easy search, search slopes were steeper, as found in Eastern cultural groups. The model showed a significant reduction in simulated accuracy below chance when *wplus* parameter was reduced by 14 %, consistent with a consistent decrease in attention as this parameter was reduced. This outcome links the *wplus* parameter with the differences found cross-culturally in earlier studies (Ueda et al., 2018; Nisbett et al., 2001b; Kitayama et al., 2003b), providing initial insights into the mechanisms behind these differences. The results are consistent with the hypothesis that one of the processes involved in cultural differences may be the perceived encoding strength of the objects presented in the visual field. These findings also align with previous research suggesting changes in early visual processing (Ueda et al., 2018; Kitayama and Murata, 2003).

The *wplus* is the coupling parameter for the group of neurons that encode specific characteristics for each position on the visual field, as previously presented by Deco and Zihl (2001) and Mavritsaki et al. (2011a). This parameter strengthens the input at each individual position, and when that input is strong the model simulates the individualist version of the model (Mavritsaki and Humphreys, 2016c). We suggest that the model with reduced *wplus* simulates collectivist behaviour in visual attention (Kitayama et al., 2003a; Nisbett et al., 2001b), where

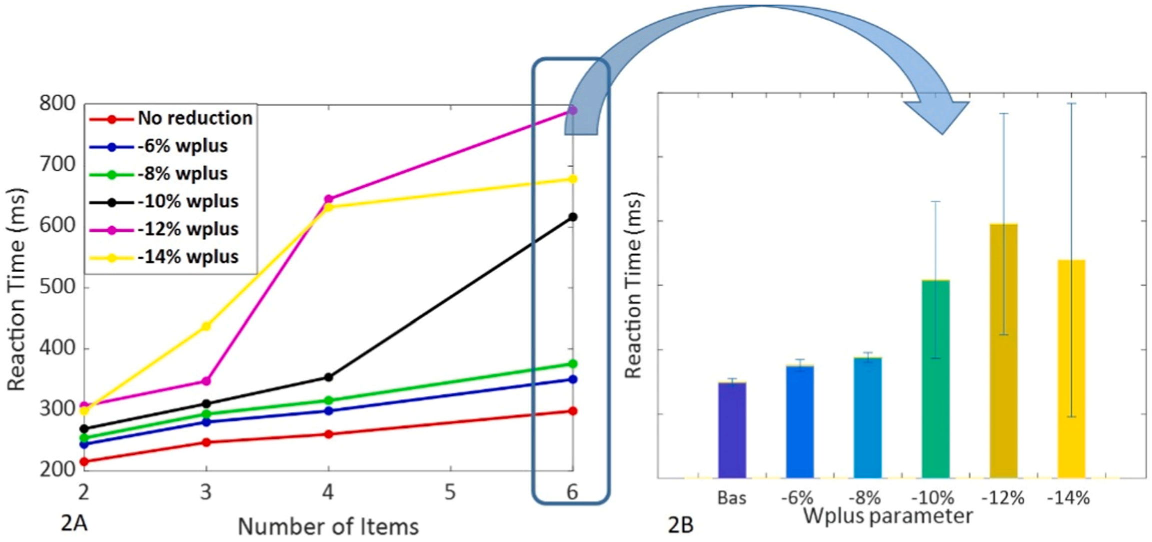

Fig. 2. The figure presents the Reaction Times for different levels of wplus parameter. Fig. 2A presents the Reaction Times for different levels of wplus parameter when the number of items presented on the display are changed. Fig. 2B presents the Reaction Times for different levels of *wplus* parameter when 6 items are presented on the display.

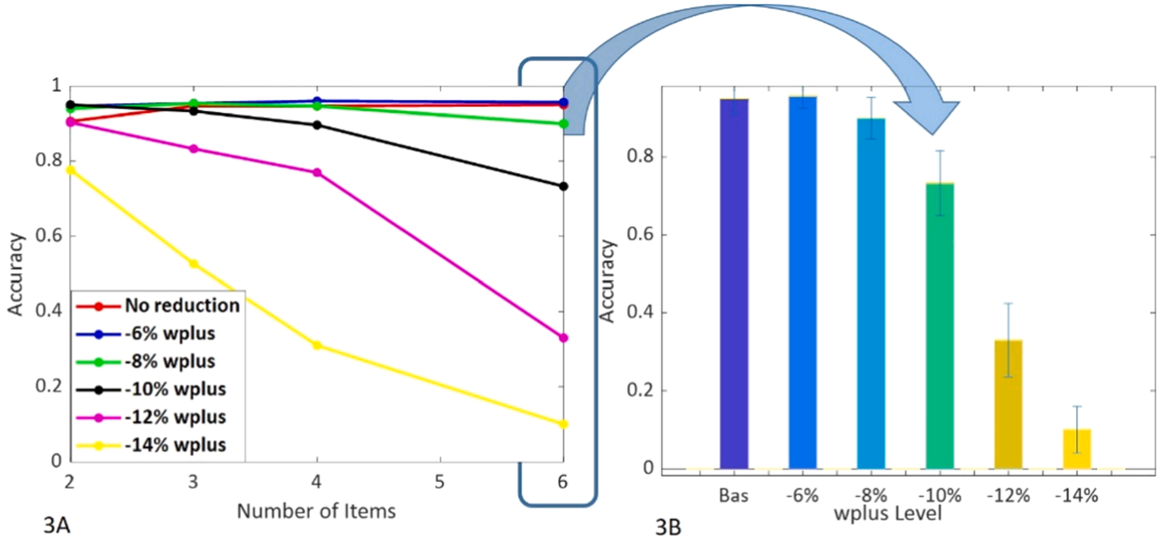

Fig. 3. The figure presents the Accuracy for different levels of *wplus* parameter. Fig. 2A presents the Accuracy for different levels of *wplus* parameter when the number of items presented on the display are changed. Fig. 2B presents the Accuracy for different levels of *wplus* parameter when 6 items are presented on the display.

the strength of the individual position is not enhanced, but rather the strength of a group of activated positions is enhanced, along with the relationship between them. Thus, the model's simulations are also consistent with cultural differences in traditional visual search experiments (Ueda et al., 2018), and picture perception studies (Nisbett et al., 2001b; Kitayama et al., 2003b).

The saliency of a stimulus can influence attention allocation. This deployment of attention can be voluntary or goal-directed, as determined by the task or situation (Qu et al., 2017). Furthermore, prior experience has been recognised as an influential factor that can influence attentional deployment (Hochstein and Ahissar, 2002), therefore, cultural frameworks can script cognitive patterns such as attention and processing styles (Nisbett et al., 2001b; Kitayama and Salvador, 2017). As discussed earlier, independent self-construal has been linked to an analytic system of thought which is focused, linear, and rule-based; whereas interdependent self-construal has been associated with holistic systems of thought that encourages a wider field of attention towards objects as well as its context and its relationship to other objects (Nisbett et al., 2001b; Doherty et al., 2008). East Asians in comparison to Western Europeans and North Americans were quicker at detecting changes in contextual information in a change blindness task (Petrova et al., 2013), more sensitive to the centre-surround size illusion (Doherty et al., 2008), and more susceptible to contextual information when making line length judgements as demonstrated in the framed-line test (Kitayama et al., 2003b). Furthermore, more recent work demonstrates cultural differences in attentional orientations towards focal or contextual elements in a visual scene (Zhang and Seo, 2015), which is in line with the findings of the presented work.

Individual differences and variabilities make the prediction of eye-movements and attentional capture a scientific challenge despite the advancements in our knowledge of low-level bottom up and high-level top-down information processing (Lüthold et al., 2018). There are other processes that might be influencing the process of attentional capture between cultures and perhaps is important to investigate

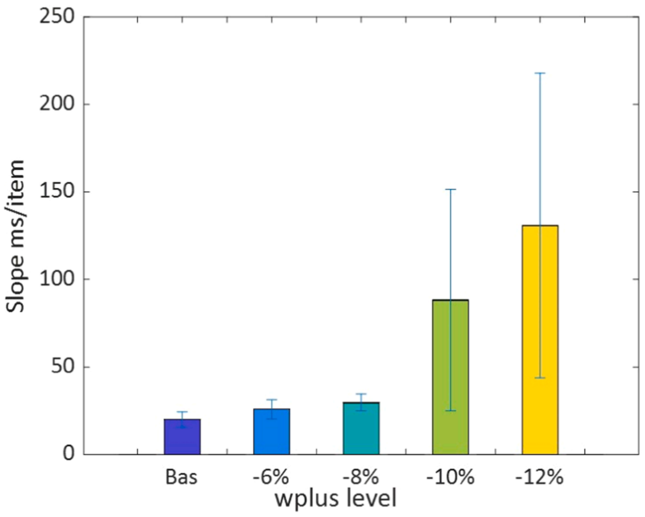

Fig. 4. The slopes for the different wplus levels are presented here.

mechanisms such culture related top-down influences in combination with changes in early visual processing (Nisbett et al., 2001a; Ueda et al., 2018; Nisbett and Masuda, 2007) with combination of computational modelling and behavioural studies. Further work is also needed to investigate not only the spatial but the temporal aspect of visual perception. Lüthold et al. (2018) found that although both East Asian and Western groups of observers exhibited similar accuracy and eye-movements, East Asians exhibited a double-checking strategy whereby they were more likely than their White counterparts to direct their gaze towards previously fixated locations and this might demonstrate different processes in visual temporal processes.

The b-sSoTS model has provided a novel insight into our understanding of how culture can influence the underlying mechanisms and processes that transpire during perceptual processing using shapes (Kitayama et al., 2003a; Ueda et al., 2018; Petrova et al., 2013; Cramer et al., 2016). Moreover, this research also provides a new perspective on why different cultural groups show varying attentional strategies when viewing different types of stimuli (Ueda et al., 2018a). When individuals have more time to process information cultural differences tend to decrease. Conversely, when mental resources are limited (e.g. if they are under pressure) cultural differences become more prominent, as people naturally default to their most familiar cultural patterns of perception (Hong and Chiu, 2005).

This research has implications for various fields, including driving and patient rehabilitation. For instance, the computational model could be used to investigate how to improve the reduced attention observed in individuals from collectivist cultures during driving tasks. Furthermore, this model could leverage data from both individualist and collectivist cultures to enhance the diagnosis and treatment of attention-related conditions, such as visual neglect. Ultimately, this approach can contribute to advancements in attention research and its applications.

Ethics declarations

This article contains no studies with human participants or animals performed by the authors. All procedures followed were in accordance with the ethical standards of the BCU ethics committee on human experimentation with the Helsinki Declaration of 1975, as revised in 2008.

CRediT authorship contribution statement

Rentzelas Panagiotis: Writing – review & editing, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Allen Harriet:** Writing – review & editing, Writing – original draft, Validation, Conceptualization. **Chua Stephanie:** Writing – review & editing, Writing – original draft, Validation, Formal analysis, Conceptualization. **Mavritsaki Eirini:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

No funding was received to assist with the preparation of this manuscript. The authors have no competing interests to declare that are relevant to the content of this article.

Acknowledgments

The computations described in this paper were performed using the University of Birmingham's BEAR Cloud service, which provides flexible resource for intensive computational work to the University's research community. See http://www.birmingham.ac.uk/bear for more details.

Data availability statement

The data that support the findings of this study are available from the corresponding author, E.M., upon request.

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