Attention, Perception, & Psychophysics (2026) 88:184
https://doi.org/10.3758/s13414-026-03327-3

SHORT REPORT

Arousal does not enhance the dominant spatial scope of attention

Martin Kolnes[1,2] · Sander Nieuwenhuis[2]

Received: 20 October 2025 / Accepted: 28 July 2026

Abstract
A fundamental aspect of attention is its spatial scope: whether attention is narrowly focused or more broadly distributed across the visual field. Here, we examined whether the spatial scope of attention is modulated by tonic arousal level. Based on findings that arousal amplifies the selectivity of attention and memory, we hypothesized that arousal would enhance the currently dominant spatial scope of attention (narrow or broad). Participants ($N=39$) performed a visual search task designed to measure the breadth of attention. Continuous auditory white noise was presented in half of the blocks to increase tonic arousal. Each trial started with a procedure that aimed to induce a narrow or broad breadth of attention. Pupil size measurements and visual search task performance revealed that the manipulations of arousal and breadth of attention were successful. However, we found strong Bayesian evidence against an amplifying effect of arousal on the dominant attentional scope. We discuss the implications of this finding for arousal-biased competition theory.

Open practices statement This research was not preregistered. Subject-level data and the analysis code are openly available in the Open Science Framework (OSF) repository (https://osf.io/6rkwg/). The raw data are available from the corresponding author upon reasonable request.

Keywords Arousal · Attentional scope · Breadth of attention · Arousal-biased competition · Drift diffusion model

Introduction

Levels of arousal, the activation of the central and autonomic nervous systems, can influence human cognition and behaviour. Sometimes arousal has general effects on behavioural state, such as an increase in alertness and readiness for action (Brown et al., 2015; Nieuwenhuis et al., 2011). However, arousal can also have more complex and dynamic effects on cognitive processes such as perception and memory, sometimes enhancing them, at other times impairing them (Mather et al., 2016). One theory that explains these complex effects of arousal on cognition is the arousal-biased competition (ABC) theory (Hockey, 1970; Mather & Sutherland, 2011). This theory is built on the assumption that processing information is a competitive process, in which different stimuli compete for limited resources. Certain stimuli, including highly salient and goal-relevant signals, receive competitive advantage over other stimuli. According to ABC theory, the selective processing of these stimuli is further enhanced by arousal, meaning that arousal strengthens the representation of these stimuli while simultaneously weakening the representation of less conspicuous ones. These winner-take-all dynamics have been demonstrated across various cognitive processes, including bottom-up and top-down attention (Cornsweet, 1969; A. P. Smith, 1982; Sutherland & Mather, 2012); but see Ásgeirsson & Nieuwenhuis, 2017, 2019), expectation (Hockey, 1970; A. P. Smith, 1985), memory (Sakaki et al., 2014), and higher-level decision-making (Wichary et al., 2016).

Here, we were interested in whether arousal also enhances the currently dominant spatial scope of attention—that is, whether attention is narrowly focused on a small area of the visual field or broadly distributed over a larger area (Eriksen & St James, 1986). In line with other studies that tested the ABC theory (Ásgeirsson & Nieuwenhuis, 2017; Mather et al., 2016), we asked participants to respond to neutral stimuli that were presented in the context of a task-irrelevant arousal manipulation. The participants' level of tonic arousal was manipulated

✉ Martin Kolnes
martin.kolnes@ut.ee

1 Institute of Psychology, University of Tartu, Näituse 2, 50409 Tartu, Estonia

2 Institute of Psychology, Leiden University, Leiden, The Netherlands

using loud and sustained (auditory) white noise (e.g., Ásgeirsson & Nieuwenhuis, 2017). Their breadth of attention was manipulated using a global motion task (Lawrence et al., 2020) in which participants were asked to report whether an array of dots, within either a small or large circle (varied across trials), was moving in a clockwise or counterclockwise direction (Fig. 1A). As this task requires integrating information from the entire circle, it should be effective at distributing attention across the entire circle, rather than just its perimeter. On each trial, we measured the impact of arousal on breadth of attention using a visual search task. Participants were asked to detect a target ellipse among distractors, which was presented either centrally or peripherally. Using this task, Kolnes et al. (2023) found that a narrow breadth of attention enhanced visual search for targets near the centre of the screen, while a broad breadth of attention enhanced visual search for targets farther away from the centre of the screen. Here, we asked whether higher arousal levels boosted this effect of attentional breadth (i.e., the current scope of attention), in line with ABC theory. To analyse performance on the visual search task, we did not only examine reaction times (RTs) and error rates, but also used a drift diffusion model (DDM), allowing an unambiguous quantification of performance differences between task conditions.

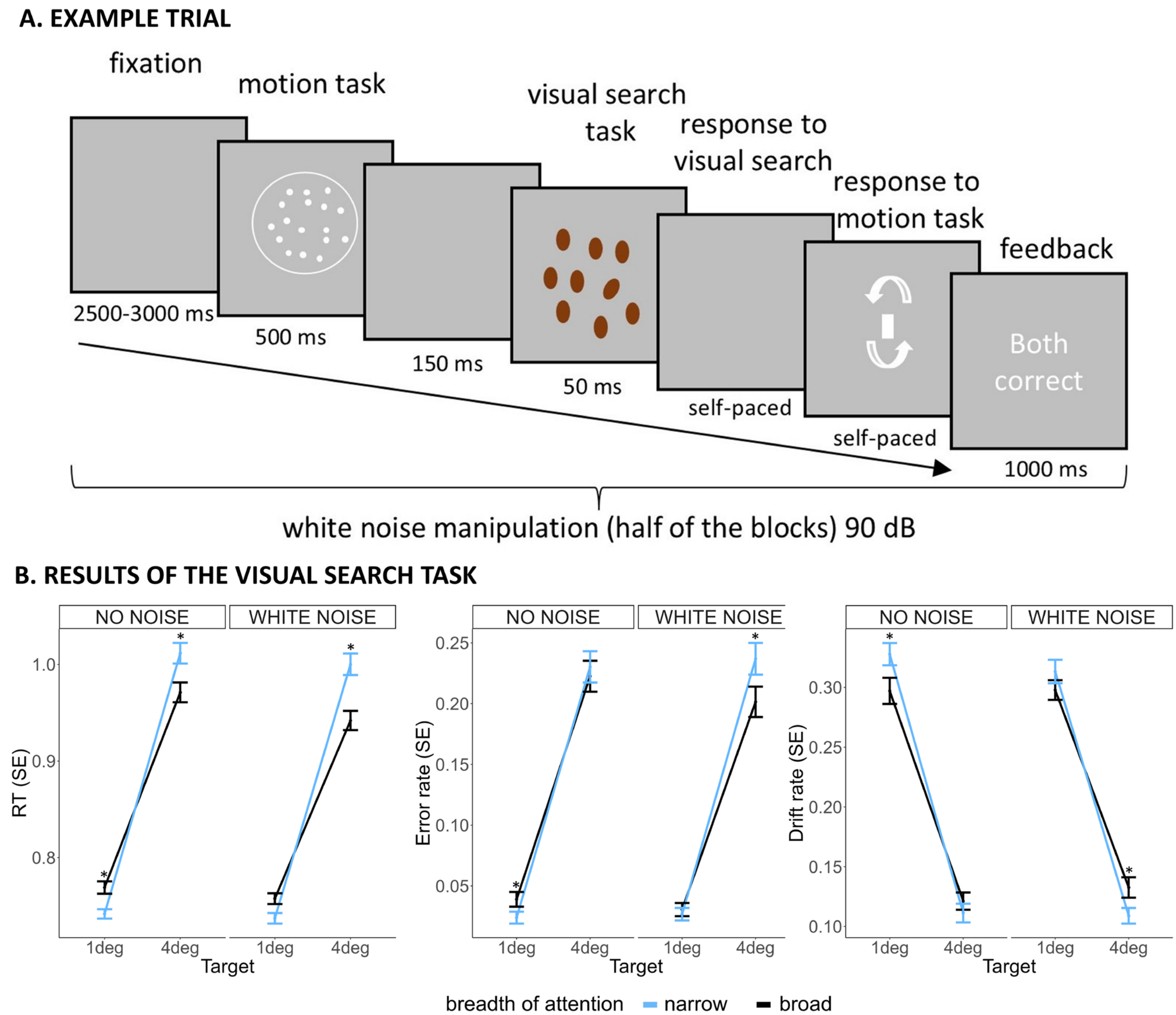

Fig. 1 **A**. Example of a trial. **B.** Results of the visual search task. Asterisks indicate significant simple main effects of breadth of attention after Holm correction ($p < .05$)

Method

Participants

Forty-seven Leiden University students participated in return for course credits or €12.50. This sample size was chosen based on a simulation-based power analysis in R using the *simr* package (Green & MacLeod, 2016). Based on interim data ($N = 22$), simulations assumed a three-way interaction effect of $\beta = 0.06$ and indicated that approximately 45 participants were required to achieve 80% power at $\alpha = .05$. After pre-processing, the final sample included 39 participants (29 women; age range: 18–35; $M_{age} = 20.5$).

Procedure

The experiment consisted of four blocks of 64 trials, each lasting approximately 7 min. There were eight experimental conditions, defined by three factors: (1) narrow versus broad attentional breadth induction, (2) centrally versus peripherally located target in the visual search task, and (3) auditory white noise vs. no noise. At the start of the experiment, participants practiced each task separately for eight trials. They then practiced the full trial sequence without white noise and with white noise, for eight trials each.

Each trial included a fixation period, attentional breadth induction using a global motion task, attentional breadth measurement using a visual search task, response reminders, and feedback (Fig. 1A). An eye tracker monitored participants' gaze location. Upon the detection of central fixation, the fixation display was presented for a random duration between 2,500 and 3,000 ms. If fixation was not detected (2.1% of the trials), the period was extended by an additional 2,000 ms before the trial continued. Omitting these trials did not change the outcome of the pupil analyses.

Following the fixation period, participants performed a global motion task, used to manipulate attentional breadth (Lawrence et al., 2020). Participants were asked to determine and remember whether the majority of dots in a circle moved in a clockwise or counterclockwise direction. The white dots were presented on a grey background in a circle of one of two sizes: a small circle (radius of 1.25° of visual angle, containing 18 dots, half of the trials in each block) or a large circle (radius of 10°, containing 740 dots, other half of the trials), with the small circle inducing a narrower focus and the large circle inducing a broader focus. The dot density was approximately 3.68 dots/degree^2. The dots had an inner radius of 0.024° of visual angle. The spatial step of the dots was set to 0.19°, with a movement speed of 5.76°/s. The lifetime of each dot was limited to 2 frames. To maintain an accuracy of approximately 82% in each condition (narrow and broad), we used separate QUEST staircase procedures to dynamically adjust the percentage of dots moving in a single direction.

Next, in the visual search task (based on Kolnes et al., 2023), participants had to locate a target ellipse among distractor ellipses presented in dark red on a grey background. Eight ellipses were displayed within a central area slightly smaller than the large circle in the motion task (radius of 7°). Seven distractor ellipses were randomly positioned, all oriented identically, and one target ellipse was tilted 25° to the left or the right. The target was either centrally (1°) or peripherally located (4° from the centre of the screen). Each ellipse measured 0.9° in height and 0.65° in width. The minimum distance between ellipses was 0.45° vertically and 0.33° horizontally. The visual search display was presented for 50 ms to discourage eye movements during the task. Immediately afterward, participants had to indicate, as quickly and accurately as possible, whether the target ellipse was tilted to the left or the right using the arrow keys on a keyboard.

Next, a response reminder for the global motion task was presented, prompting participants to indicate whether the overall motion was counterclockwise or clockwise using the "W" and "S" keys, respectively. Finally, participants received feedback on their performance in both the global motion task and the visual search task.

To systematically manipulate participants' arousal levels, continuous loud white noise (90 dB) was presented through headphones throughout half of the blocks. In the blocks without noise, participants wore the same headphones. For half of the participants, the noise was presented in the first and third blocks (ABAB), for the other half the noise was presented in the second and fourth blocks (BABA). To prevent carry-over effects, a 5-min break was provided between blocks. The full experiment lasted 50–60 min.

Preprocessing of behavioural data

First, participants with an error rate exceeding 45% in at least one of the eight cells of the experimental design were excluded from all analyses, resulting in the removal of eight participants. Second, for each participant and cell of the design, the median RT and median absolute deviation (MAD) were calculated, and trials with RTs falling outside three MADs from the median were excluded. This step resulted in the exclusion of 6.28% of the data. All participants had at least 50% of their data retained in every cell of the design.

Preprocessing of pupil data

Pupil size was recorded at a sampling frequency of 60 Hz using a Tobii Sparks eye tracker, and the *PupillometryR* package in R was used for data preprocessing. First, blinks identified by the eye tracker were extended both forward and backward by 100 ms to account for artifacts related to eye movements. Next, data were filtered using a median filter with a polynomial degree of 11 to reduce noise. Missing values at the start and end of the trials were extrapolated, and linear interpolation was applied to the remaining missing data points to generate continuous pupil measurements. Finally, the average pupil size in a 1,000-ms window prior to motion task onset was used for analyses. Trials with more than 50% missing raw data were discarded ($M = 2.3\%$). One participant was excluded due to high data loss (more than 50% of trials). Pupil data were z-scored within each participant.

Drift diffusion model (DDM) analysis

The DDM analysis was conducted on the pre-processed data from the visual search task, including both correct and error trials. To capture the underlying cognitive processes involved in decision-making, we used the EZ diffusion model (Wagenmakers et al., 2007), which derives three key parameters from accuracy and RT data: drift rate, nondecision time, and boundary separation. Our primary focus was on the drift rate, which reflects the average speed of evidence accumulation toward one of two decision thresholds (e.g., whether the target ellipse is tilted left or right) and is modulated by attention through its influence on the effective quality of incoming perceptual evidence. Nondecision time and boundary separation were not sensitive to any of the task variables.

Statistical analysis

Correct RTs, error rates and the DDM parameter drift rate were analysed using (generalized) linear mixed-effects models, using the *lme4* and *lmerTest* packages in R. All predictors were deviation-coded. In line with the recommendations of Barr and colleagues (2013), we initially specified the most complex random-effects structure supported by the design—that is, when possible, models included both random intercepts and random slopes for all within-subject fixed effects (white noise, breadth of attention, and target distance) and their interactions. If a model failed to converge, the random structure was gradually simplified by removing random slopes in a stepwise manner. The final models were as follows:

$$RT\ model: RT \sim noise \times breadth\ of\ attention \times target\ distance + (1 + noise + breadth\ of\ attention + target\ distance \mid participant)$$

$$Error\ rate\ model: error\ rate \sim noise \times breadth\ of\ attention \times target\ distance + (1 \mid participant)(binomial\ GLMM)$$

$$Drift\ rate\ model: drift\ rate \sim noise \times breadth\ of\ attention \times target\ distance + (1 \mid participant$$

To evaluate the strength of evidence in favour of the alternative or null hypothesis, we conducted Bayesian repeated-measures ANOVAs. Model comparisons were performed across the full model space, and Bayes factors were computed for each effect using the *BFinclusion* approach, which quantifies the strength of evidence for including a specific effect in the model compared with models excluding it (Wagenmakers et al., 2018). Model priors were specified to reflect noninformative assumptions about effect inclusion. A uniform model prior was used, meaning that all possible models (i.e., combinations of main effects and interactions) were considered equally likely a priori. For the coefficient priors, the default Cauchy prior scales were used: fixed effects: $r = 0.5$; random effects: $r = 1$; covariates: $r = 0.354$. Bayes factors were interpreted according to established conventions (Lee & Wagenmakers, 2014).

Results

Manipulation check: Arousal manipulation was successful

To assess whether pupil-linked arousal was affected by the white noise manipulation, we first regressed out time-on-task effects (similar to Ásgeirsson & Nieuwenhuis, 2017) using a simple linear regression with pre-trial baseline pupil size as the dependent variable and trial number in block as the independent variable. A repeated-measures mixed ANOVA of the residuals with condition (noise vs. no noise) and condition order (ABAB or BABA, nuisance variable) as independent variables indicated that baseline pupil size was larger in the noise blocks ($M = 4.45$ mm, $SD = 0.72$) than in the no-noise blocks ($M = 4.37$ mm, $SD = 0.67$), $F(1,36) = 12.31$, $p < .01$, general $\eta^2 = 0.25$, $BF_{incl} = 5.9 \times 10^7$ (Supplementary Table S1 and S2).

Manipulation check: Breadth-of-attention manipulation was successful

The average accuracy in the motion task was 85.5% (based on the end-of-trial responses to the motion task). Accuracy was lower in the narrow-breadth-of-attention condition compared to the broad-breadth-of-attention condition (84.1% vs. 86.9%), $t(38) = 4.12$, $p < .001$, suggesting that the staircase procedure was more effective in the narrow condition, converging more closely on the target accuracy level of 82%.

To assess whether the breadth-of-attention manipulation was successful, we used linear mixed models predicting measures of visual search performance in the visual search task (RT, accuracy, drift rate) based on noise versus no noise, breadth of attention (narrow vs. broad), and target distance from the centre of the screen (1° vs. 4°). Importantly, all three measures of visual search performance showed significant cross-over interactions between breadth of attention and target distance (Table 1). These interactions indicated that visual search was impaired for more eccentric targets (4°), but less so in the broad breadth-of-attention condition (Fig. 1B). Likewise, visual search was improved for more central targets (1°), but less so in the broad breadth-of-attention condition. These findings suggest that the breadth-of-attention manipulation was successful.

White-noise manipulation did not enhance the dominant attentional scope

As shown in Table 1, our arousal manipulation had no main or interaction effects on any of the three measures of visual search performance. Specifically, the main effect of white noise provided strong evidence against inclusion in the statistical model, with Bayes factors ranging from $BF_{incl} = 0.12$ to 0.27. Similarly, the two-way interaction between white noise and target distance showed moderate evidence against inclusion ($BF_{incl} = 0.13$ to 0.25), suggesting that arousal did not cause an overall broadening or narrowing of the scope of attention (cf. Easterbrook, 1959). Finally, the critical three-way interaction between white noise, breadth of attention, and target distance provided moderate to strong evidence against inclusion ($BF_{incl} = 0.02$ to 0.16). So, contrary to our key hypothesis, arousal did not amplify the effects of breadth of attention on visual search.

Fluctuations in pupil-linked arousal did not modulate the dominant attentional scope

We conducted an additional, exploratory analysis to examine whether spontaneous fluctuations in pre-trial baseline pupil size modulated the effects of breadth of attention on visual search. Note that these fluctuations were an order of magnitude larger (e.g., Δ 1 st vs. 4th quartile ≈ 1 mm) than the effect of white noise on pupil size (0.09 mm, reported above). We fitted linear mixed-effects models predicting RTs and error rates from single-trial measures of baseline pupil size, white noise (present vs. absent), attentional breadth and target distance, including all interactions between predictors (see Supplementary Materials for full models and tables.

Table 1 Inferential statistics of reaction times, error rates, and drift rate in the visual search task

Effect	RT			Error rate			DDM: drift rate		
	Estimate	*p*	BF_{incl}	*Odds ratio*	*p*	BF_{incl}	*Estimate*	*p*	BF_{incl}
white noise	−0.02	.32	0.27	0.77	.25	0.12	0.001	.96	0.19
Breadth of attention	0.01	.08	1233.80	0.61	**.043**	0.17	0.03	**.013**	3.13
Target distance	0.23	**<.001**	2.6×10^{14}	7.27	**<.001**	2.3×10^{10}	−0.18	**<.001**	1.2×10^{14}
White noise × breadth of attention	0.01	.29	0.23	1.44	.30	0.09	−0.02	.38	0.32
White noise × target distance	−0.01	.25	0.25	1.14	.59	0.13	0.01	.54	0.25
Breadth of attention × target distance	0.07	**<.001**	5191.73	1.72	**.040**	0.33	−0.04	**.019**	15.72
White noise × breadth of attention × target distance	0.003	.89	0.09	0.82	.60	0.02	0.002	.95	0.16

Default levels: white noise = yes; breadth of attention = narrow; target distance = 4. Frequentist analyses were conducted using linear mixed-effects models fitted to the trial-level data. Bayesian analyses were conducted on participant-level condition means using repeated-measures ANOVAs in JASP

The analyses revealed a significant main effect of baseline pupil size on RTs (Table S3), indicating that trials with larger pupil-linked arousal were associated with slower RTs. However, critically, baseline pupil size did not modulate the significant interaction between attentional breadth and target distance, which reflects the effect of our breadth-of-attention manipulation, nor the three-way interaction between white noise, attentional breadth and target distance (Table S3). Thus, although baseline pupil size was related to overall task performance, it did not amplify the attentional breadth effects central to our hypotheses. The same pattern was observed in the error-rate analysis (Table S4).

Discussion

The aim of this study ($N = 39$) was to examine whether arousal modulates the currently dominant spatial scope of attention. Building on the framework of ABC theory, we hypothesized that heightened arousal would enhance the task-relevant scope of attention: narrow or broad. To test this hypothesis, we manipulated attentional breadth on a trial-by-trial basis using a global motion task, and tonic arousal by presenting loud white noise. Both manipulations were successful. However, contrary to our expectations, arousal did not influence the dominant scope of attention: All three dependent variables showed moderate ($BF_{incl} < 0.33$) to strong ($BF_{incl} < 0.125$) Bayesian evidence for the null hypothesis. Spontaneous fluctuations in pupil-linked arousal did also not bias the currently dominant attentional scope.

These results seem inconsistent with the predictions of ABC theory (Mather & Sutherland, 2011). Target stimuli in the centre and periphery of the visual search display had higher or lower priority, depending on the induced breadth of attention. Therefore, we expected that arousal would improve visual search for centrally presented targets when attention was narrowly focused, while improving peripheral search when attention was more broadly distributed. Our task design had high top-down demands by requiring goal-directed modulation of attentional breadth. In this regard, the null findings align with other experiments that have failed to replicate arousal-driven modulations of top-down visual attention (Ásgeirsson & Nieuwenhuis, 2017). On the other hand, several studies have found that arousal enhances recall of stimuli or stimulus dimensions with high top-down priority, while impairing recall of information with low top-down priority (Sakaki et al., 2014; A. P. Smith, 1982). Another study found that arousal amplified the processing of task-relevant visual cues, regardless of whether these were presented in a central or peripheral location (Cornsweet, 1969). Together, these results provide mixed evidence for an arousal-related competitive advantage for mental representations with top-down priority.

Our finding that the white-noise manipulation had no main or two-way interaction effect on any measure of visual search performance may raise a concern about the success of our arousal manipulation. However, we believe this concern is not warranted. First, the presentation of continuous, loud auditory white noise is one of the most widely used methods—particularly in the absence of affective content—for increasing baseline arousal. During the 1970 s and 1980 s, a period marked by growing interest in human factors, numerous studies employed this approach to investigate the effects of environmental noise (e.g., in industrial settings) on cognitive performance (reviewed in A. Smith, 1989). Second, auditory white noise at moderate-to-high intensities (≤ 90 dB) has been shown to enhance the selectivity of perception (e.g., O'Malley & Poplawsky, 1971; A. P. Smith, 1985) and memory (e.g., Hockey & Hamilton, 1970; O'Malley & Poplawsky, 1971).

Notably, these are some of the key findings cited in support of the ABC theory, which inspired our experiment. Third, white noise had a robust effect on pupil size, the most commonly used peripheral index of central arousal. And fourth, the relationship between pupil-linked arousal and cognitive performance is generally nonlinear and context-dependent, rather than reflecting a simple monotonic improvement with increasing arousal (Beerendonk et al., 2025; de Gee et al., 2014; van den Brink et al., 2016).

Indeed, a limitation of our study is that our binary manipulation of arousal level did not allow us to identify a potential curvilinear relationship between arousal and the dominant spatial scope of attention. That is, our null results can in principle be explained by assuming that (i) the effect of arousal on the dominant spatial scope of attention follows an inverted U curve (cf. Bundesen et al., 2015); and that (ii) the low-arousal and high-arousal conditions in our experiment placed the participants at points to the left and right of the curve's optimum that were associated with similar effects. Excluding this scenario requires a more rigorous test, involving the manipulation of arousal over multiple levels.

Finally, it is important to note that the present study examined the effects of arousal on trial-by-trial changes in attentional breadth. Therefore, the results do not exclude the possibility that arousal may affect the ability to maintain a particular breadth of attention over a longer period of time.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.3758/s13414-026-03327-3.

Author contributions M.K.: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Visualization, Writing—original draft, and Writing—review & editing.

S.N.: Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Resources, Writing—original draft, and Writing—review & editing.

Funding This research was funded by the Estonian Research Council (grants PUTJD1174 and KOHTO16) awarded to Martin Kolnes, and by a Vici grant (VI.C.181.032) awarded to Sander Nieuwenhuis, funded by the Dutch Research Council (NWO).

Data availability The processed data are openly available in the OSF repository (https://osf.io/6rkwg/). The raw data are available from the corresponding author upon reasonable request.

Code availability The analysis scripts are openly available in the OSF repository (https://osf.io/6rkwg/).

Declarations

Ethics approval The study was approved by the Leiden University Psychology Research Ethics Committee.

Consent to participate All participants provided written informed consent.

Consent for publication All participants provided written informed consent for publication of the anonymized data.

Conflicts of interest The authors declare that they have no conflicts of interest.

References

Ásgeirsson, Á. G., & Nieuwenhuis, S. (2017). No arousal-biased competition in focused visuospatial attention. *Cognition, 168*, 191–204. https://doi.org/10.1016/j.cognition.2017.07.001

Ásgeirsson, Á. G., & Nieuwenhuis, S. (2019). Effects of arousal on biased competition in attention and short-term memory. *Attention, Perception, & Psychophysics, 81*(6), 1901–1912. https://doi.org/10.3758/s13414-019-01756-x

Barr, D. J., Levy, R., Scheepers, C., & Tily, H. J. (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language*. https://doi.org/10.1016/j.jml.2012.11.001

Beerendonk, L., Mejías, J. F., Nuiten, S. A., de Gee, J. W., Zantvoord, J. B., Fahrenfort, J. J., & van Gaal, S. (2025). Adaptive arousal regulation: Pharmacologically shifting the peak of the Yerkes-Dodson curve by catecholaminergic enhancement of arousal. *Proceedings of the National Academy of Sciences of the United States of America, 122*(28), Article e2419733122. https://doi.org/10.1073/pnas.2419733122

Brown, S. B. R. E., Tona, K.-D., van Noorden, M. S., Giltay, E. J., van der Wee, N. J. A., & Nieuwenhuis, S. (2015). Noradrenergic and cholinergic effects on speed and sensitivity measures of phasic alerting. *Behavioral Neuroscience, 129*(1), 42–49. https://doi.org/10.1037/bne0000030

Bundesen, C., Vangkilde, S., & Habekost, T. (2015). Components of visual bias: A multiplicative hypothesis. *Annals of the New York Academy of Sciences, 1339*, 116–124. https://doi.org/10.1111/nyas.12665

Cornsweet, D. M. (1969). Use of cues in the visual periphery under conditions of arousal. *Journal of Experimental Psychology, 80*(1), 14–18. https://doi.org/10.1037/h0027115

de Gee, J. W., Knapen, T., & Donner, T. H. (2014). Decision-related pupil dilation reflects upcoming choice and individual bias. *Proceedings of the National Academy of Sciences of the United States of America, 111*(5), E618–E625. https://doi.org/10.1073/pnas.1317557111

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review, 66*(3), 183–201.

Eriksen, C. W., & St James, J. D. S. (1986). Visual attention within and around the field of focal attention: A zoom lens model. *Perception & Psychophysics, 40*(4), 225–240. https://doi.org/10.3758/BF03211502

Green, P., & MacLeod, C. J. (2016). SIMR: An R package for power analysis of generalized linear mixed models by simulation. *Methods in Ecology and Evolution, 7*(4), 493–498. https://doi.org/10.1111/2041-210X.12504

Hockey, G. R. (1970). Signal probability and spatial location as possible bases for increased selectivity in noise. *Quarterly Journal of Experimental Psychology, 22*(1), 37–42. https://doi.org/10.1080/14640747008401899

Hockey, G. R., & Hamilton, P. (1970). Arousal and information selection in short-term memory. *Nature, 226*(5248), 866–867. https://doi.org/10.1038/226866a0

Kolnes, M., Uusberg, A., & Nieuwenhuis, S. (2023). Broadening of attention dilates the pupil. *Attention, Perception, & Psychophysics*. https://doi.org/10.3758/s13414-023-02793-3

Lawrence, R. K., Edwards, M., Talipski, L. A., & Goodhew, S. C. (2020). A critical review of the cognitive and perceptual factors influencing attentional scaling and visual processing. *Psychonomic Bulletin & Review, 27*(3), 405–422. https://doi.org/10.3758/s13423-019-01692-9

Lee, M. D., & Wagenmakers, E.-J. (2014). *Bayesian cognitive modeling: A practical course*. Cambridge University Press.

Mather, M., Clewett, D., Sakaki, M., & Harley, C. W. (2016). Norepinephrine ignites local hotspots of neuronal excitation: How arousal amplifies selectivity in perception and memory. *Behavioral and Brain Sciences, 39*, Article UNSP e200. https://doi.org/10.1017/S0140525X15000667

Mather, M., & Sutherland, M. R. (2011). Arousal-biased competition in perception and memory. *Perspectives on Psychological Science, 6*(2), 114–133. https://doi.org/10.1177/1745691611400234

Nieuwenhuis, S., De Geus, E. J., & Aston-Jones, G. (2011). The anatomical and functional relationship between the P3 and autonomic components of the orienting response. *Psychophysiology, 48*(2), 162–175. https://doi.org/10.1111/j.1469-8986.2010.01057.x

O'Malley, J. J., & Poplawsky, A. (1971). Noise-induced arousal and breadth of attention. *Perceptual and Motor Skills, 33*(3), 887–890. https://doi.org/10.2466/pms.1971.33.3.887

Sakaki, M., Fryer, K., & Mather, M. (2014). Emotion strengthens high-priority memory traces but weakens low-priority memory traces. *Psychological Science, 25*(2), 387–395. https://doi.org/10.1177/0956797613504784

Smith, A. (1989). A review of the effects of noise on human performance. *Scandinavian Journal of Psychology, 30*(3), 185–206. https://doi.org/10.1111/j.1467-9450.1989.tb01082.x

Smith, A. P. (1982). The effects of noise and task priority on recall of order and location. *Acta Psychologica, 51*(3), 245–255. https://doi.org/10.1016/0001-6918(82)90037-3

Smith, A. P. (1985). Noise, biased probability and serial reaction. *British Journal of Psychology, 76*(Pt 1), 89–95. https://doi.org/10.1111/j.2044-8295.1985.tb01933.x

Sutherland, M. R., & Mather, M. (2012). Negative arousal amplifies the effects of saliency in short-term memory. *Emotion, 12*(6), 1367–1372. https://doi.org/10.1037/a0027860

van den Brink, R. L., Murphy, P. R., & Nieuwenhuis, S. (2016). Pupil diameter tracks lapses of attention. *PLoS ONE, 11*(10), Article e0165274. https://doi.org/10.1371/journal.pone.0165274

Wagenmakers, E.-J., Van Der Maas, H. L. J., & Grasman, R. P. P. P. (2007). An EZ-diffusion model for response time and accuracy. *Psychonomic Bulletin & Review, 14*(1), 3–22. https://doi.org/10.3758/BF03194023

Wagenmakers, E.-J., Love, J., Marsman, M., Jamil, T., Ly, A., Verhagen, J., & Morey, R. D. (2018). Bayesian inference for psychology. Part II: Example applications with JASP. *Psychonomic Bulletin & Review, 25*(1), 58–76. https://doi.org/10.3758/s13423-017-1323-7
Warren, C. M., Murphy, P. R., & Nieuwenhuis, S. (2016). Cognitive control, dynamic salience, and the imperative toward computational accounts of neuromodulatory function. *Behavioral and Brain Sciences, 39*, Article e227. https://doi.org/10.1017/S0140525X15001983
Wichary, S., Mata, R., & Rieskamp, J. (2016). Probabilistic inferences under emotional stress: How arousal affects decision processes. *Journal of Behavioral Decision Making, 29*(5), 525–538. https://doi.org/10.1002/bdm.1896

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.