

SUPPLEMENTARY METHODS AND MATERIAL

Data analysis

Objective Performance: Type 1 AUC

To estimate subjects' objective discrimination accuracy regardless of response criterion, we adopted signal detection theory [1] to calculate Type 1 performance. To construct a Type 1 receiver operating characteristics (ROC) curve, we regarded a trial in which the correct response was either 'same', 'male', or 'red-green' as a signal-present trial. Conversely, trials in which the correct response was either 'different', 'female', or 'green-red' were regarded as signal-absent. Starting from the most stringent criterion, a signal-present response with subjective rating 4 was defined as a 'hit' in a signal-present trial and 'false alarm' in a signal-absent trial. Then, in the second most stringent criterion, we regarded a signal-present response with rating 4 and 3 in a signal-present trial as a hit and in a signal-absent trial as a false alarm, and so on. With the most lenient criterion, we considered any signal-present response and signal-absent response with rating 1, 2 and 3 in a signal-present trial as hit and in a signal-absent trial as false alarm. Thus, we shifted the criterion in 7 steps to obtain a 7-inflection ROC curve. The area under this ROC curve (Type 1 AUC) was then computed to provide a non-parametric estimate of objective accuracy for each attention condition [2,3,4,5].

Metacognitive accuracy: Type 2 AUC

To examine whether subjects categorise stimuli using information accessible to consciousness, we quantified metacognitive accuracy as Type 2 discrimination performance using signal detection theory [2,6,7,8]. Using the signal conventions described above, we first categorised trials as correct or incorrect. Correct responses were those where subjects made a signal-present side response in a signal-present trial or signal-absent side response in a signal-absent trial, regardless of the level of subjective rating. Otherwise, we regarded that trial as incorrect.

Trials were then classified according to rating. First, we regarded a correct trial (regardless of whether the signal was present or not) with rating of 4 as 'hit' and an incorrect trial with rating 4 as 'false alarm', and so on. We

shifted the criterion in 3 steps to obtain a 3-inflection ROC curve. The area under the resulting ROC curve (Type 2 AUC) was then adopted as a non-parametric estimate of metacognitive accuracy for each attention condition [2,4,6,7].

Linear mixed effects (LME) metacognitive analysis

We used linear mixed-effect (LME) analysis to examine if trial-by-trial subjective ratings are affected by spatial attention and task accuracy. We used the *lme4* package [9] within R to model subjective ratings as our dependent variable with the fixed effects of attention, correctness, and their interaction. As a random effect we included intercepts for subjects. As a significance test, we performed likelihood ratio tests between the full model and a reduced model that excluded the factor of interest. In the case of a significant interaction effect, we subset data into each level of the attention or correctness factors and performed a likelihood ratio test against a null model with the random intercept for subjects only [2].

Tradeoff analysis

When performance measures for both central and peripheral tasks under the dual-task condition are the same as those under their respective single-task conditions, discrimination for the peripheral task is considered not to rely on top-down attentional amplification [10,11,12]. When performance is not identical between the conditions, we need to consider *tradeoff* between the tasks.

In Supplementary Figure 1, we plot hypothetical single-task performance for the central (dark blue circle) and peripheral (light blue circle) task on the x- and y- axes, with the origin corresponding to chance-level performance for each task. We plot a hypothetical dual-task performance with its x- and y- coordinate corresponding to the central and peripheral performance in the dual-task condition (black circles within axes). If there is no tradeoff, the dual-task performance should locate at the corner (black circle highlighted in red). The line connecting the two single-task points (black diagonal) represents complete tradeoff between the tasks. To quantify the level of tradeoff we calculate the trigonometric altitude, or the shortest

distance between the observed dual-task performance (black circle highlighted in salmon) and complete tradeoff line. We define the *actual trigonometric altitude* (salmon line, TA^{actual}) as the observed altitude as a proportion of the altitude for no-tradeoff dual-task performance (red line, TA^{theory}).

Adjustment of SOAs and α parameters during training in Experiment 3

In Experiment 3, to equate discrimination performance across subjects and between both face and disk aspects of the blended stimuli in the single-task condition, we employed QUEST to adjust SOA (with the same parameter settings as in Exp 1 and 2) or α parameters (QUEST parameter β of 3 and standard deviation of 0.3).

As training, subjects completed 10 blocks of single-task (30 trials per block) and 2 blocks dual-task (20 trials per block). In blocks 1 and 2 we adjusted α values for the single-peripheral-disk and single-peripheral-face conditions. We adjusted SOAs in block 3, 4, and 5 (single-central-letter, single-peripheral-disk, then single-peripheral-face conditions). This procedure for α and SOA staircasing was repeated in blocks 6 through 10. During single-task blocks with α adjustment, SOAs were fixed, and vice versa.

The α parameter of both the face and disk aspect of the blended stimulus were adjusted such that subjects' performance was 70% for that stimulus type. To ensure the overall luminance of the peripheral stimulus was consistent, the sum of these α parameters was always equal to 1. For instance, in blocks 1 and 2, SOA for the peripheral stimulus was initially fixed at 250ms. This meant the discrimination task was relatively easy so α levels tended to be low to achieve 70% performance threshold (for instance, $\alpha_{\text{Face}} \approx 0.2$ and $\alpha_{\text{Disk}} \approx 0.8$ in the single-peripheral-face task, $\alpha_{\text{Face}} \approx 0.7$ and $\alpha_{\text{Disk}} \approx 0.3$ in the single-peripheral-disk task).

In single-task blocks with SOA adjustment the α level for each aspect of the blended stimulus was computed by averaging between the threshold α values from the previous α adjustment blocks. To ensure this averaging retained an overall α of 1, mean α for disk (α_{mDisk}) and face (α_{mFace}) were computed as follows. In blocks 3, 4, and 5 from the example outlined above, mean α levels would be:

$$\alpha_{mDisk} = \frac{\alpha_{Disk} + (1 - \alpha_{Face})}{2} = \frac{0.3 + (1 - 0.2)}{2} = 0.55$$
$$\alpha_{mFace} = \frac{\alpha_{Face} + (1 - \alpha_{Disk})}{2} = \frac{0.2 + (1 - 0.3)}{2} = 0.45$$

SOA for the peripheral stimulus was then adjusted to achieve 70% performance accuracy for the relevant stimulus (for instance, in the example provided we would expect SOA to be shorter than 250ms for both disks and faces). The mean SOA across peripheral conditions was then applied to the next α adjustment block and the staircasing procedure was repeated in blocks 6 through 10.

This process meant we efficiently established SOAs and α values with which each subject performed the single-peripheral-face and single-peripheral-disk tasks at 70% accuracy. To complete training, subjects were presented with 20 trials of the dual-task peripheral-face + central-letter condition and 20 trials of the dual-task peripheral-disk + central letter condition. In this and subsequent dual-task blocks, mean SOA and mean α levels were applied from the preceding block. This ensured stimulus appearance was identical for both dual-task conditions.

Supplementary references:

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