Supplementary Materials

A. The qVA Method

In the qVA method (Patent US10758120B2; Lesmes & Dorr, 2019; Zhao et al., 2021), a single-optotype d′ psychometric function (Figure S1a) is described as:

$$d'(os_{ijk}, \boldsymbol{\theta}_{ij}) = \log_{10}(6) + \frac{\omega}{2\beta_{ij}}\left(os_{ijk} - \alpha_{ij}\right) - \frac{1}{2}\log_{10}(8 + 10^{\frac{\omega}{\beta_{ij}}(os_{ijk}-\alpha_{ij})}), \quad \text{(S1)}$$

where $\boldsymbol{\theta}_{ij} = (\alpha_{ij}, \beta_{ij})$; α_{ij} is VA threshold, corresponding to the optotype size at d'=2, β_{ij} is the VA range of the psychometric function, that is, the range of optotype sizes that covers d'=1 to d' =4 performance levels, and $\omega = \log_{10} 35 - \log_{10} 1.25$. The smaller the range is, the steeper the slope of the psychometric function. From this single-optotype d' psychometric function, qVA derives the probabilities of obtaining correct identification of different numbers of optotypes (Figure S1c; $f\left(\mathrm{g}\left(os_{ijk}, \boldsymbol{\theta}_{ij}\right), n\right)$) from the single-optotype psychometric function of percent correct (Figure S1b; $\mathrm{g}\left(os_{ijk}, \boldsymbol{\theta}_{ij}\right)$) derived from the $\mathrm{d}'(os_{ijk}, \boldsymbol{\theta}_{ij})$ based on signal detection theory (Green & Swets, 1966), taking into account of the particular chart design. In this paper, a 10 alternative forced-choice task (n = 10) was implemented in the qVA method, and the probability of individual *i*'s response r_{ijk} (the number of correct identifications: 0,1,2,3) of the three optotypes with optotype size os_{ijk} in trial *k* of test *j* is:

$$p\left(r_{ijk} \middle| \boldsymbol{\theta}_{ij}, os_{ijk}\right) = f\left(\mathrm{g}\left(os_{ijk}, \boldsymbol{\theta}_{ij}\right), n\right). \quad \text{(S2)}$$

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B. MCMC in JAGS

Each random walk in the MCMC started at a randomly selected position in the 232-dimensional parameter space. In each step, one of the 232 parameters was selected randomly. The one-dimensional conditional posterior probability distribution of the selected parameter was

evaluated by fixing the values of all the other 231 parameters at the current position. A new value of the selected parameter was chosen based on the one-dimensional conditional probability distribution (Eq. 6). By reiterating this process, the probability of visiting a location in the random walk approximated the joint posterior distribution of all the 232 parameters in Eq. 6.

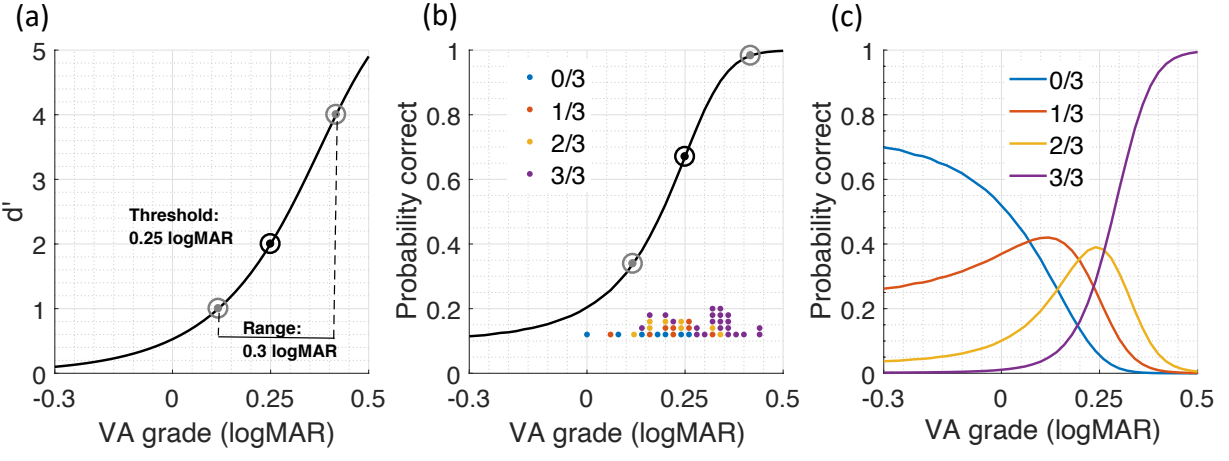

Figure S1. Example psychometric functions in the qVA method. (a) The single-optotype d' psychometric function for an observer with VA threshold = 0.25 logMAR and VA range = 0.3 logMAR. (b) The single-optotype psychometric function of percent correct, i.e., the probability of correct identification of a single optotype as a function of the optotype size in a 10-AFC task, for the observer in (a). Stimulus selections and responses for the observer in one qVA simulation are shown as colored dots, with different colors indicating different numbers of correctly identified optotypes. (c) The multi-optotype psychometric functions of the observer, i.e., the probabilities of correctly identifying 0, 1, 2, or 3 of the three same-size optotypes presented on each row as functions of optotype size.