Supplementary material

[1] AM Two-down-one-up (TDOU) rule and threshold performance level

The AM method in the manuscript uses the ‘two-down-one-up’-rule to determine the mask delay of the following trial. After two correct responses, that do not necessarily have to occur in sequence, the delay becomes shorter and thus the task more difficult. The mask delay (and the task difficulty) will be decreased after each incorrect response. The reason why this procedure converges at a performance level of 66.67% is explained in the following paragraph.

In case of the basic ‘one up-one down’ method, the delay increases with each incorrect answer and decreases with each correct response. With this rule, the series will converge towards a threshold at which 50% of correct answers will be achieved [1]. However, since a 50% performance may be reached by answering randomly, it is common practice to select thresholds for higher performance levels. At the convergence of the adaptive procedure with any rule for increasing or decreasing stimulus parameters, the probability of increasing the delay, p_{up}, and decreasing the delay, p_{down}, is 50% [1]. If p_c is the probability to obtain a correct response and n is the number of trials which are taken into account, the number of trials in which the delay will be decreased is thus $\frac{1}{2}np_c$ in case of the TDOU rule. Furthermore, $n(1-p_c)$ will be the number of trials in which the delay will be increased. Finally, the probability for a decreasing and an increasing value will be $p_{down} = \frac{\frac{p_c}{2}}{\frac{p_c}{2}+(1-p_c)} = \frac{p_c}{2-p_c}$, and $p_{up} = \frac{1-p_c}{\frac{p_c}{2}+(1-p_c)} = \frac{2-2p_c}{2-p_c}$, respectively. At the convergence of the two probabilities, $p_{down} = p_{up} = \frac{1}{2}$, p_c will be 0.667. Note, that the rule does not require two correct responses in sequence to decrease the delay.

[2] Estimation of threshold in the framework of Signal Detection Theory

The fundamental assumption of SDT is that sensory inputs, such as the masked sad or happy face, are represented as continuous variables, referred to as sensory representations. A probability density function that is usually assumed to be normally distributed provides the probability of a certain face representation being perceived as a happy face (Fig.S1). An alternative probability density function characterizes the perception of a sad face (Fig.S1). A large overlap of the two probability density functions indicates that the observer has difficulties to discriminate the corresponding stimuli. In contrast, a large distance d', between the peaks of the probability density functions indicates high discrimination performance. Given the sensory representation and the probability density functions, SDT assumes that a criterion g is used to come to a sensory decision. If the sensory representation exceeds the decision criterion g the stimulus will be perceived as a happy face. Inversely, if the sensory representation is below the criterion, the stimulus will be reported to be a sad face. The criterion for sensory decisions might vary according to previous information and decision biases. Both, sensitivity d' and criterion g can be estimated based on the response behavior, i.e. the number of hits (the percentage of correctly identified happy faces), correct rejections (the percentage of correctly identified sad faces), misses (incorrectly perceiving the happy face as sad) and false alarms (incorrectly perceiving the sad face as happy) (Table S1).

For a normal distribution for happy and sad faces with mean and standard deviation m_H and s_H, m_S and s_S, respectively, d' is defined as:

$$d' = \frac{m_H - m_S}{\sqrt{\frac{1}{2}\left(s_H^2 + s_S^2\right)}}$$

Assuming standard deviations of 1 for happy and sad face stimuli, d' can be inferred from measurements of the hit rate and false alarm rate (Fig.S1):

$d' = Z(p_H) - Z(p_F)$, where $Z(p)$, $p \in [0,1]$ is the inverse of the cumulative distribution function of the Gaussian distribution.

The criterion g equals to:

$$g = \frac{1}{2}\left(Z(p_H) + Z(p_F)\right)$$

Plotting hit rates as a function of false alarms will result in the 'Receiver Operating Characteristic' (ROC) [2-4]. The ROC describes the sensitivity (d') independent of any bias. Therefore, ROC curves are iso-sensitive functions with variable levels of bias [5]. The Fig.S1e shows the perceptual representations described in Fig.S1a, b, c, d plotted in a ROC. It is noticeable that each curve in the graph is representing the same sensitivity value, Fig.S1a and Fig.S1b as well Fig.S1c and Fig.S1d are part of the same curve despite the different bias levels appear as different points in the same curves. The data presented in Fig.S1a, b, c, d can be fitted on the psychometric function to calculate the threshold. The different bias values evidently influence the threshold value, for values lower than $g = 0$

		Perception	
		Happy face	Sad face
Stimulus	Happy face	Hit (H)	Miss (M)
	Sad face	False Alarm (F)	Correct Rejection (C)

Table S1: Representation of the subject's responses in dependence of the presence or absence of the stimulus.

Typically, when studying the threshold for the perception of emotional face stimuli, the bias that might be introduced by focusing on features that are related to either to the happy or the sad face is ignored, and only the percentage of corrected trials, i.e. $\frac{n_{hit} + n_{correct\,rejection}}{n_{hit} + n_{correct\,rejection} + n_{misses} + n_{false\,alarms}}$, is considered. Thus, sensory thresholds might be distorted and do not reflect the observer's' real performance.

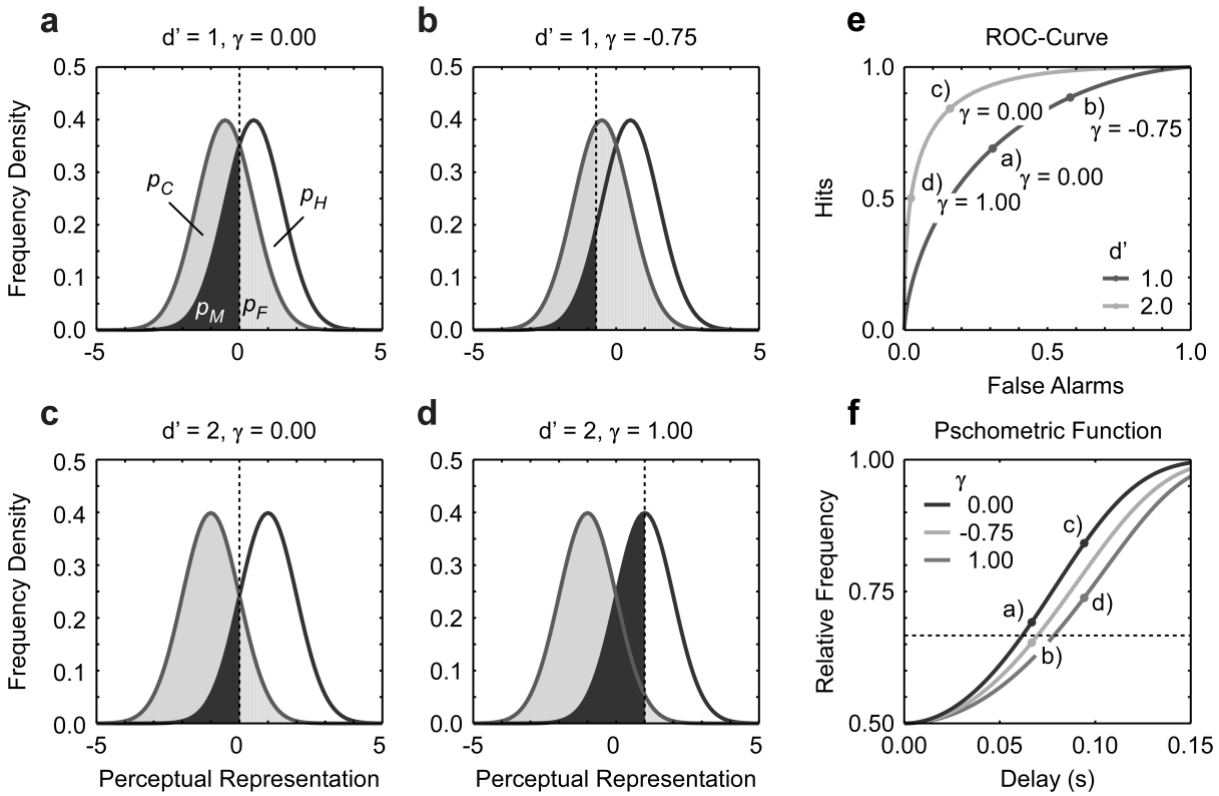

Fig.S1 a-d: *SDT probability distributions for perceiving happy and sad faces depending on the perceptual representation of the stimulus based on* d' *and the criterion position* g*. In figures a) and b),* d'*, the distance between both peaks, is smaller than in c) and d), and thus stimuli are more difficult to discriminate. While in b) a shift of the criterion in the direction of sad faces increases a bias towards happy faces, in c) a shift of the discrimination criterion in the direction of happy faces causes an increased bias for choosing sad face responses. e) The ROC curve represents the previously described distributions. f) shows the data of the distributions fitted to the psychometric function to calculate the respective threshold values.*

Fig.S1a and Fig.S1c illustrate the situation in which the criterion is set at 0 ($g=0$) with a different degree of sensitivity with $d'=1$ (Fig.S1a) and $d'=2$ (Fig.S1c). The perceptual representation of the observer improves in the second case (Fig.S1c), represented by the greater area under the curves (hit rate and correct rejection areas) as compared to the areas displayed in the Fig.S1a. Furthermore, the influence of the criterion position is shown in Fig.S1b and Fig.S1d. In the first case, with the criterion set at $g<0$, the hit rate has a higher value than in case of a bias. At the same time, the percentage of false alarm has also increased. In contrast, for a criterion $g>0$, the hit rate as well as the false alarm are lower, whereas there is a higher percentage of correct rejections and misses. Examples in Fig. S1b, S1d and S1f show that a bias different from zero is increasing the individual's threshold.

References

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