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# Thresholds for detection and awareness of masked facial stimuli

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ABSTRACT

It has been suggested that perception without awareness can be demonstrated by a dissociation between performance in objective (forced-choice) and subjective (yes–no) tasks, and such dissociations have been reported both for simple stimuli and more complex ones including faces. However, signal detection theory (SDT) indicates that the subjective measures used to assess awareness in such studies can be affected by response bias, which could account for the observed dissociation, and this was confirmed by Balsdon and Azzopardi (2015) using simple visual targets. However, this finding may not apply to all types of stimulus, as the detectability of complex targets such as faces is known to be affected by their configuration as well as by their stimulus energy. We tested this with a comparison of forced-choice and yes–no detection of facial stimuli depicting happy or angry or fearful expressions using a backward masking paradigm, and using SDT methods including correcting for unequal variances in the underlying signal distributions, to measure sensitivity independently of response criterion in 12 normal observers. In 47 out 48 comparisons there was no significant difference between sensitivity ($d_a$) in the two tasks: hence, across the range of expressions tested it appears that the configuration of complex stimuli does not enhance detectability independently of awareness. The results imply that, on the basis of psychophysical experiments in normal observers, there is no reason to postulate that performance and awareness are mediated by separate processes.



## 1. Introduction

A considerable body of research has been directed towards the question of whether perception can occur without awareness. This ongoing interest not only reflects the philosophical debate as to whether perception implies consciousness, but also has implications for understanding the functional architecture of the visual system. If performance can be dissociated from awareness, either through neurological damage as in the case of blindsight (Weiskrantz, 1986), or through degraded stimulus conditions presented to normal observers (e.g. Meeres & Graves, 1990) it would suggest that information can influence performance through different neural pathways than those mediating conscious awareness.

Demonstrating perception without awareness requires a dissociation between performance on a measure of perception and a measure of awareness. However, there remains considerable controversy as to what constitutes an appropriate indicator of awareness. Cheesman and Merickle (1984) distinguished between the subjective threshold, which they defined as the stimulus energy level at which observers *claim* not to be able to discriminate perceptual information above chance, and the objective threshold, which they defined as the level at which observers are *actually* unable to discriminate perceptual

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information above chance. Whilst some researchers have argued that awareness should always be assessed using objective measures of perceptual discrimination (e.g. Eriksen, 1960; Holender, 1986), Cheesman and Merickle (1986) argued that objective measures provide conservative indicators of awareness, and that a subjectively defined awareness threshold best captures the distinction between conscious and unconscious experiences. Following from their finding that the objective threshold is associated with somewhat lower stimulus energy levels than the subjective threshold indicated by subjects' self-reports (Cheesman & Merickle, 1984), they suggest that unconscious processing may occur only for stimuli presented at energy levels between the objective and the subjective thresholds, with stimuli above the subjective threshold being consciously processed, and stimuli below the objective threshold undergoing no processing whatsoever. According to this formulation, performance should reach chance level at a lower stimulus energy for objective (i.e. forced choice) tasks than for subjective (i.e. yes–no) tasks; hence there should be intermediate stimulus levels at which observers perform at chance in a subjective task but above chance in an objective task. Such dissociations have been reported in several studies: for example, Meeres and Graves (1990) found that observers were able to detect a masked target shape significantly above chance in a spatial forced-choice task (i.e. in which of two possible spatial locations a stimulus was presented) despite being unable to detect the stimuli in a yes–no task.

There is, however, a potentially serious problem with dissociations which are based on percentage correct scores in subjective and objective tasks because, according to signal detection theory (SDT) (Green & Swets, 1966), percentage scores reflect not only an observers' sensitivity to stimuli, but also their response bias. As illustrated in Fig. 1, SDT assumes that internal signals associated with presentation of a stimulus (S+) is normally distributed about a mean, and the internal signals associated with the absence of a stimulus (S−) is also distributed around a lower mean value. Decisions about whether a particular internal signal was caused by S+ or S− require an observer to set a criterion value, c, above which they respond S+ and below which they respond S− As the two distributions overlap this will result in both correct responses (hits and correct rejections) and mistakes (false alarms and misses) with the proportions of correct responses and errors – and hence the percentage correct scores – depending not only on the observer's sensitivity but also on the position of their response criterion. Use of a conservative response criterion in the yes–no task may depress an observer's percentage correct score relative to a force choice task: the accuracy of observers' decision about which of two spatial or temporal intervals contained a stimulus should be unaffected by response bias provided that the stimuli are randomly distributed with respect to the spatial or temporal interval. Hence any dissociation of performance and awareness based on differential accuracy in forced-choice compared to yes–no tasks may simply reflect the influence of response bias.

SDT provides a measure of sensitivity ($d'$) which is independent of response criterion and therefore avoids the problem of response bias (Green & Swets, 1966). Assuming that the two underlying distributions of signals associated with S+ and S− are normal and have equal variances, then the difference between the means of the distributions in units of standard deviation can be given by $d' = z(H) - z(F)$, where $H$ (hit rate) = (number of hits/number of S + s) and $F$ (false alarms rate) = (number of false alarms/number of S − s), and $z$ is the inverse of the normal distribution function.

Despite the fact that SDT is well established, the possibility that response bias can account for the difference between objective and subjective thresholds has been consistently ignored or actively dismissed by the majority of researchers in perception without awareness (e.g. Dixon, 1971, 1981). In some cases, SDT methods have been applied inappropriately in order to lend credibility to findings established through potentially biased methods. For example, Meeres and Graves (1990) conducted a *post hoc* analysis of their localization and detection data to calculate $d'$ reporting a dissociation of sensitivity in the two task consistent with their main finding. However, Meeres & Graves did not test for the equality of variances of the two underlying distributions. This is a critical assumption in calculating $d'$: if the variances are not equal, $d'$ does not provide a reliable measure of sensitivity because the value obtained will vary according to the response criterion.

Given that the widespread claims of dissociations between performance and awareness in normal observers are based on measures susceptible to response bias, it is of general interest to know whether the dissociations stand up when truly bias-

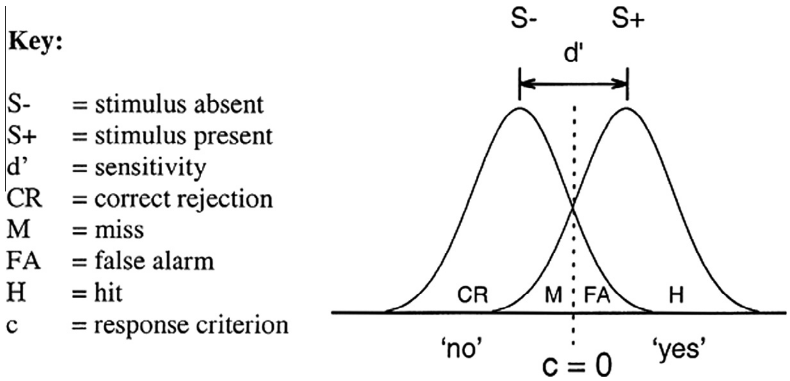


**Fig. 1.** Signal detection theory.