

# Dissociation Between Recognition and Detection Advantage for Facial Expressions: A Meta-Analysis

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Happy facial expressions are recognized faster and more accurately than other expressions in categorization tasks, whereas detection in visual search tasks is widely believed to be faster for angry than happy faces. We used meta-analytic techniques for resolving this categorization versus detection advantage discrepancy for positive versus negative facial expressions. Effect sizes were computed on the basis of the  $r$  statistic for a total of 34 recognition studies with 3,561 participants and 37 visual search studies with 2,455 participants, yielding a total of 41 effect sizes for recognition accuracy, 25 for recognition speed, and 125 for visual search speed. Random effects meta-analysis was conducted to estimate effect sizes at population level. For recognition tasks, an advantage in recognition accuracy and speed for happy expressions was found for all stimulus types. In contrast, for visual search tasks, moderator analysis revealed that a happy face detection advantage was restricted to photographic faces, whereas a clear angry face advantage was found for schematic and “smiley” faces. Robust detection advantage for nonhappy faces was observed even when stimulus emotionality was distorted by inversion or rearrangement of the facial features, suggesting that visual features primarily drive the search. We conclude that the recognition advantage for happy faces is a genuine phenomenon related to processing of facial expression category and affective valence. In contrast, detection advantages toward either happy (photographic stimuli) or nonhappy (schematic) faces is contingent on visual stimulus features rather than facial expression, and may not involve categorical or affective processing.

*Keywords:* facial expression, emotion, recognition, visual search, meta-analysis

*Supplemental materials:* <http://dx.doi.org/10.1037/emo0000042.supp>

Humans communicate their emotions using facial signals, some of which are thought to be basic and culturally more or less invariant (Ekman, 1992). These signals convey messages regarding the relationship between the expresser and their environment. Happy smiles can be perceived as invitations for engaging in cooperation and pleasurable interaction, whereas angry snarls provide warning signals of possible psychological or physical threat (Scherer & Wallbott, 1994). Neurocognitive models of emotional processing have postulated that emotional signals conveyed by facial expressions are processed by specialized brain circuits, and that processing of emotional over neutral information would be facilitated at both detection and recognition stages (Öhman & Mineka, 2001; Vuilleumier, 2005). This ensures that information conveyed by emotional signals is brought

swiftly under detailed scrutiny by the sensory systems, and consequently used for adjusting behavior to cope with the adaptive challenges in the environment. Cognitive studies have indeed shown that emotional signals capture attentional resources more readily than neutral ones (Nummenmaa, Hyönä, & Calvo, 2006; Öhman, Flykt, & Esteves, 2001) and are categorized quickly in less than 200 milliseconds (Nummenmaa, Hyönä, & Calvo, 2010).

However, as facial expressions have different social functions, an important yet unresolved issue is the relative advantage in the recognition and detection of different emotional expressions. Stimulus *detection* (i.e., noticing that an object is in an array of stimuli) can be accomplished on the basis of physical feature processing, whereas its *recognition* involves identification of the stimulus meaning and determining what the object is rather than merely noticing it (Grill-Spector & Kanwisher, 2005). Theoretically, recognition and detection of both negative (i.e., fearful, angry) and positive (i.e., happy) emotions<sup>1</sup> could be facilitated: Angry facial expressions signal interpersonal conflicts and potentially dangerous interactions (Lundqvist, Esteves, & Ohman, 1999); thus, de-

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This research was supported by the aivoAALTO project of the Aalto University, Academy of Finland Grant #251125 to LN and ERC Starting Grant #313000 to LN.

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<sup>1</sup> We reckon that, in addition to happiness, other nonbasic emotions and expressions (e.g., pride) are associated with positive valence. However, the research on facial expression recognition and that of visual search of expressions is predominated by the basic expression view, and very little evidence exists on the processing of nonhappy positively valenced emotions and their expressions. Consequently, the conceptualization of positive emotions pertains only to happy faces for the sake of conciseness.

tecting them early could enable avoiding physical and psychological harm. Similarly, happy faces have important adaptive functions in social interaction by facilitating cooperation with, and influence on, other people (Johnston, Miles, & Macrae, 2010); thus, their efficient recognition would secure such important social benefits.

There is, nevertheless, a discrepancy in the literature with respect to the relative recognition and detection advantage of different facial expressions. In studies on facial expression *recognition*, participants are typically asked to consciously categorize facial expressions to a limited number of preexisting categories. These studies have consistently shown that happy expressions are recognized faster and more accurately than any other basic emotional expression including anger, fear, sadness, disgust, and surprise (see Calder, Young, Keane, & Dean, 2000; Leppänen & Hietanen, 2003; Nelson & Russell, 2013). In contrast, visual search studies involving facial expression targets typically use eye movement or manual responses to quantify how quickly the visual and attentional systems can *detect* (but not necessarily categorize) affectively discrepant items across the visual field. In this type of study, facilitated attentional detection has typically been reported for angry rather than happy faces in visual search tasks with schematic faces (Eastwood, Smilek, & Merikle, 2001; Öhman, Lundqvist, & Esteves, 2001) and sometimes with photographic faces (Fox & Damjanovic, 2006). The assumption of an angry face detection advantage has reached almost a canonical status in the literature (see, e.g., conclusions by Frischen, Eastwood, & Smilek, 2008), yet contrary evidence has been accumulating (Becker, Anderson, Mortensen, Neufeld, & Neel, 2011; Calvo & Nummenmaa, 2008; Juth, Lundqvist, Karlsson, & Ohman, 2005).

Here we reconcile these conflicting views by means of quantitative meta-analytic techniques. We show that the happy face advantage in expression *recognition* is a genuine phenomenon that occurs across different types of stimuli and cannot be explained by visual confounds of the facial expressions. However, the advantage in expression *detection* is contingent on the type of stimulus employed: Whereas search tasks using photographic face stimuli result in a happy face advantage, those involving schematic faces yield an opposite, non-happy or angry face advantage. Because low-level stimulus properties governing early attention orienting (Borji & Itti, 2013; Itti & Koch, 2001) differ across both schematic and photographic facial expressions, we propose that the presumed “affect-driven” effects in visual search are most likely due to low-level sensory rather than emotional features.

### Facilitated Recognition of Happy Faces

Happy expressions are categorized and discriminated more accurately and faster than the other basic expressions of emotion. A consistent happy face recognition advantage in recognition speed and/or accuracy has been observed in laboratory studies comparing all the six basic emotional categories (Calder et al., 2000; Calvo & Lundqvist, 2008; Tottenham et al., 2009) and also in those using subsets of expressions (Juth et al., 2005; Leppänen & Hietanen, 2004; Loughhead, Gur, Elliott, & Gur, 2008; Svård, Wiens, & Fischer, 2012). It has been found in studies using different response modalities including manual (Calvo & Lundqvist, 2008) verbal (Palermo & Coltheart, 2004) and saccadic (Calvo & Nummenmaa, 2009) responses, and also in two-alternative forced

choice (2AFC) tasks where participants discriminate between expressions of face pairs (rather than singly presented faces) shown simultaneously (Calvo & Nummenmaa, 2009; Calvo & Nummenmaa, 2011).

The effect is also consistent across different types of face stimuli. It has been found with all the most widely used facial stimulus databases, including the Pictures of Facial Affect (Ekman & Friesen, 1976), Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998), NimSTIM (Tottenham et al., 2009), Montreal Set of Facial Displays of Emotion (Beaupré, Cheung, & Hess, 2000), or the Japanese and Caucasian Facial Expressions of Emotion (JACFEE; Matsumoto & Ekman, 1988). Importantly, the happy face advantage occurs even when the models show closed-mouth rather than open-mouth smiles with exposed teeth (Tottenham et al., 2009), and even when simple schematic “smiley” face stimuli are used (Kirita & Endo, 1995; Leppänen & Hietanen, 2004). Finally, the happy face recognition advantage is reliable across cultures. Although facial expressions may not be completely culturally universal, a recent review of 21 cross-cultural studies with 57 datasets indicates that the average recognition agreement is higher for happy than for the other five basic expressions, consistently across literate western and non-western cultures, as well as illiterate isolated cultures (Nelson & Russell, 2013).

A substantial body of evidence also suggests that expressive information is extracted more efficiently from happy versus other expressions. Happy faces are recognized with shorter stimulus exposures than other expressions (Calvo & Lundqvist, 2008; Esteves & Ohman, 1993; Svård et al., 2012), and the relative recognition advantage for happy versus other faces actually increases when stimulus exposure becomes shorter: Decreasing display duration significantly impairs recognition of all the facial expressions more than that of happy faces (Calvo & Lundqvist, 2008). In line with this, happy faces are less effectively pre- and postmasked (Milders, Sahraie, & Logan, 2008; Svård et al., 2012). As masking truncates ongoing visual processing (Breitmeyer & Ogmen, 2000), these findings show that less visual information is required for expression categorization of happy versus other faces.

In line with this, happy faces are also recognized more effectively in peripheral vision (Calvo, Fernández-Martín, & Nummenmaa, 2014; Calvo, Nummenmaa, & Avero, 2010; Goren & Wilson, 2006). Whereas recognition of all the other facial expressions is substantially impaired when seen outside the fovea, recognition of happy faces is only minimally influenced by their distance from current fixation (Calvo et al., 2014). Consequently, the relatively low-spatial-resolution magnocellular channels projecting from the peripheral retina must convey the expressive information that is critical for happy face recognition, whereas recognition of other expressions would have to rely more on the high-resolution parvocellular output stemming primarily from the fovea.

Three different accounts have been proposed to explain the happy face recognition advantage. First, an *affective uniqueness* hypothesis would posit that happy faces are recognized faster and more accurately because they are the only clearly pleasant emotion category. Consequently, recognition of the different negative expressions (anger, fear, disgust, and sadness) would be susceptible to affective interference due to shared affective value (Mendolia, 2007), thus resulting in relatively faster recognition of happy faces. Second, the *diagnostic value* hypothesis postulates that specific

facial features—particularly the visually conspicuous smiles—are consistently associated with happiness, thus providing a short-cut for quick featural recognition of the happy expressions (Calvo, Fernández-Martín, & Nummenmaa, 2012; Calvo & Nummenmaa, 2008; Calvo et al., 2010). Third, the *frequency of occurrence* hypothesis states that happy faces are the most frequently encountered facial expression in social settings (Calvo, Gutierrez-Garcia, Fernández-Martín, & Nummenmaa, 2014; Somerville & Whalen, 2006), thus tuning the visual system for an efficient recognition of these faces. However, the relative contribution of each postulated mechanism for the happy face recognition advantage remains unresolved.

### Is There a Detection Advantage for Some Facial Expressions?

Given that happy expressions seem to be recognized faster than any other expression across the visual field and particularly in the periphery, it would be logical to expect that happy faces would be detected faster in crowded visual arrays (thus with stimuli appearing outside of foveal vision). A number of studies employing the visual search paradigm have tackled this question. In this paradigm, participants are asked to search for a discrepant target (e.g., a happy face) among an array of distractors (e.g., neutral faces or arrays consisting entirely of distractors), and their task is to report whether the target was absent or present. Search times for different target types among similar distractors are compared: Facilitated detection of a specific target category is typically operationalized as faster response times on “target present” trials for some stimulus types, or shallower search slopes, that is, smaller increments in search time as a function of search array size, thus indicating more parallel search (Duncan & Humphreys, 1989; Treisman & Gelade, 1980). In the context of visual search of facial expressions, we could thus hypothesize that a happy face advantage would also be observed.

However, research seems to suggest the opposite. The earliest reports of visual search of photographic facial expressions favored the *threat advantage* hypothesis, with faster detection of angry targets among happy distractors than vice versa (Hansen & Hansen, 1988), even though this effect was subsequently found to be confounded with stimulus features—when conspicuous black spots on the original angry face stimuli were removed, the angry face advantage was abolished (Purcell, Stewart, & Skov, 1996). In subsequent experiments, researchers tried to avoid potential visual confounds, and to this end used “smiley” faces or simple schematic line drawings of faces (see Figure 1). The reasoning was that because a happy smiley face could be transformed into an angry face simply by flipping the mouth, low-level visual features would remain constant even though the configural representation and affective value of the face would be transformed. This line of research turned the tables again and confirmed that a robust threat or angry face advantage occurs with such artificial yet well controlled stimuli (Eastwood et al., 2001; Fox et al., 2000; Juth, Karlsson, Lundqvist, & Ohman, 2000; Öhman, Lundqvist et al., 2001). Many studies also found relatively shallow or near-flat search slopes (Fox et al., 2000; Öhman, Lundqvist et al., 2001), thus suggesting that angry faces could be detected using parallel search. Some studies have even found that inverting the faces does not influence the threat detection advantage, thus implying feature-

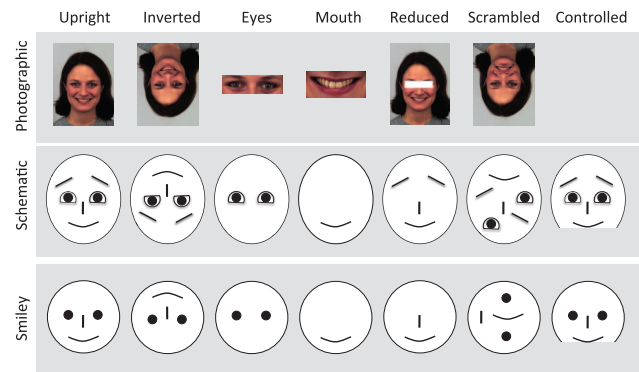


Figure 1. Summary of stimulus types included in expression recognition and visual search studies. *Note:* Facial expression photographs are from KDEF database (Lundqvist, Flykt, & Öhman, 1998). See the online article for the color version of this figure.

based search (Lipp, Price, & Tellegen, 2009b; Öhman, Lundqvist et al., 2001), but there are also opposite findings (Eastwood et al., 2001).

Subsequent work showed that this angry face advantage could be observed also with photographic faces (Lipp et al., 2009b; Pinkham, Griffin, Baron, Sasson, & Gur, 2010) and even when only the eye region of the faces is presented (Fox & Damjanovic, 2006). Overall, the angry face advantage has been argued to support the *threat detection* hypothesis, which implies that the visual system would have evolved to support facilitated detection of the survival-salient, threat-related information in angry facial expressions (Öhman, Lundqvist et al., 2001). Consistent with this, a comprehensive narrative review on visual search of facial expressions has concluded that an anger superiority of visual search of facial expressions is clearly supported by the literature (Frischen et al., 2008).

A number of studies have nevertheless found evidence that is not consistent with the angry face detection advantage. In a series of visual search experiments using photographic facial expressions, happy face detection superiority has, actually, been found. When presented among neutral faces, happy faces are detected faster than others as indexed by response latencies (Becker, Anderson et al., 2011; Calvo & Nummenmaa, 2008; Calvo, Nummenmaa, & Averó, 2008; Juth et al., 2005) and the time taken to land a first fixation on the face (Calvo & Nummenmaa, 2008; Calvo, Nummenmaa, & Averó, 2008). These studies have also taken a quite different—a visual rather than an affective—account for explaining the happy face advantage: The high saliency or conspicuity of the smiling mouth would be the critical factor driving attention to the happy faces (Becker, Anderson et al., 2011; Calvo & Nummenmaa, 2008). This argument has been supported by computational modeling of visual attention for the visual search arrays: When presented among neutral distractors, happy faces are indeed more perceptually salient or conspicuous than any other expressive faces (Calvo & Nummenmaa, 2008).

If we follow this visual or perceptual account regarding photographic happy faces, it raises the question regarding the angry face detection advantage in the visual search studies using schematic faces, which presumably involve more strictly controlled stimuli (see above). Consequently, two competing hypothesis regarding

facial expression detection can be presented. In an *emotional processing hypothesis*, some expressive content (such as the threat value) would support facilitated detection and recognition of the faces. Such a hypothesis fits well with the data from studies involving schematic faces (but possibly for those involving photographic faces, too), where low-level differences among stimuli are expected to be minimal. In contrast, a *perceptual hypothesis* would suggest that some distinctive physical instead of affective characteristics of specific facial expressions could support swift recognition and detection. This hypothesis has gained support from studies with photographic faces where visual discrepancies between expression categories do exist. However, it is still possible that the schematic faces would also be contaminated by some visual confounds favoring detection of angry expressions, which would support the perceptual hypothesis (Calvo & Nummenmaa, 2008).

### The Current Study: Meta-Analysis of Recognition and Detection Advantage for Happy Versus Angry Faces

Different studies have used different measurement (e.g., eye movement, manual, and vocal responses) and analytic (e.g., response latencies, computation of search slopes, eye movement parameters) techniques for assessing the recognition or detection advantages in facial expression processing. Also, critically, different studies have used different types of stimuli, with the greatest difference involving photographs of real faces versus schematic face-like drawings. Consequently, it is difficult to draw conclusions regarding the actual presence or absence of a happy or an angry face superiority without a quantitative summary of the independent studies. Moreover, such a synthetic approach allows for pinpointing critical differences in experimental designs that may give rise to differences in research outcomes, and ultimately deciding about the role of perceptual and emotional factors in facial expression detection and recognition. In order to resolve the discrepancies between expression categorization and visual search studies, we conducted a quantitative meta-analysis of facial expression recognition and detection. We quantified the possible advantage for recognizing or detecting happy versus other faces in each study and used a set of moderator variables to provide a numerical, evidence-based answer to the following questions:

1. Are happy faces recognized more accurately and/or faster than other expressions?

2. Can the potential recognition advantage for happy faces be explained by affective uniqueness or diagnostic value of smiles?
3. Is there an advantage in the detection of happy versus nonhappy faces in visual search studies?
4. Can the potential detection advantage to happy or nonhappy faces be better explained by an *emotional* or a *perceptual* model of facilitated attentional capture?

In brief, the overall framework for assessing the general recognition and detection advantage Questions 1 and 3 involved estimating the respective effect sizes and computing the pooled mean effect size and its confidence interval (CI). The existence of a consistent recognition and/or detection advantage would thus be revealed by mean effect sizes whose CIs do not overlap with zero.

The specific hypotheses for Questions 2 and 4 are concerned with the neurocognitive mechanisms underlying recognition and detection advantage. They were further evaluated by testing whether the effect sizes across studies would be associated with relevant differences in experimental designs and coded into a set of moderator variables summarized in Table 1.

Specifically, if affective uniqueness underlies the happy face advantage, effect sizes for the happy face recognition advantage should be linearly dependent on the number of nonhappy stimulus categories participants are asked to recognize thus increasing affective uniqueness. This was coded into moderator variable *number of categories in recognition task*. On the contrary, if diagnostic value or visual conspicuity explains the happy face advantage, the corresponding effect sizes should vary as a function of the stimulus type (schematic vs. different photographic faces) given that photographic smiles are more salient and resemble real-life smiles more closely, and that different photographic stimulus sets vary with respect of the actual visual configuration of the happy faces. This was tested using moderator variables *stimulus database* and *stimulus type*. Further, if conspicuous facial features underlie the diagnostic value of the happy faces, the happy face advantage should not be influenced by inverting faces upside down given that featural processing is known to be only minimally impaired by face inversion (Maurer, Grand, & Mondloch, 2002). This was tested using the moderator *stimulus presentation*.

With respect to expression detection, we assumed that, if the detection advantage were driven by perceptual factors, effect sizes

Table 1  
Coding Scheme For Moderator Variables and the Predictions Tested With Each Variable.

Moderator	Number of levels	Levels	Used for recognition studies	Used for visual search studies	Tested prediction for recognition	Tested prediction for detection
Number of categories in recognition task	6	2–7	Yes	—	Affective uniqueness	—
Stimulus type	3	Photographs, schematic faces, smileys	Yes	Yes	<b>Diagnostic value</b>	<b>Perceptual model</b> versus emotional model
Stimulus presentation	7	Upright, inverted, eyes only, mouth only, reduced, scrambled, controlled	Yes	Yes	<b>Diagnostic value</b>	<b>Perceptual model</b> versus emotional model
Stimulus database	5	Ekman, KDEF, JACFEE, NIMSTIM, Other	Yes	—	<b>Diagnostic value</b>	—

Note. Predictions supported by the actual meta-analysis are marked with boldface.

should be consistently different for studies using different types of stimuli (photographs, schematic, and smiley faces) as well as across different facial expression photograph sets, whereas an opposite result would favor an emotional explanation. This hypothesis was further scrutinized by evaluating whether stimulus manipulations known to reduce or remove emotional information from faces (such as inversion and rearrangement of facial features) are associated with the magnitude of the detection advantage. A significant association would provide support for the emotional hypothesis because removal of emotional information diminishes the emotionality bias. On the contrary, the lack of association would speak for the perceptual hypothesis, given that the specific face categories keep on attracting attention even when they are devoid of emotional meaning. This analysis involved the moderator variable *stimulus presentation*.

## Methods

### Literature Searches

The meta-analysis includes peer-reviewed studies written in English and published through the end of February 2013. Several search methods were used. The Web of Science, PubMed, and Scopus databases were searched to retrieve documents containing the terms *facial expression*, *emotion*, *recognition*, *detection* and *visual search* either in article title, abstract, or keywords. Articles referred to in articles found by the preceding method were examined. Studies were accepted for the meta-analysis if they met the following criteria: (a) they had investigated experimentally recognition speed or accuracy of happy and other facial expressions or (b) they had investigated detection speed of happy and other expressions embedded in neutral or expressive visual search arrays. Studies conducted in patient populations or those correlating recognition or detection performance with clinical variables were omitted as were those using other types of attention tasks such as the dot-probe: Our focus was on attentional detection of facial expressions in healthy populations, and other paradigms such as dot-probe measure also other attentional processes such as disengagement. Altogether the meta-analysis database included data from 34 recognition studies with 3,561 participants and 37 visual search studies with 2,455 participants. The studies included in the meta-analysis are marked with an asterisk in the References section.

### Overall Framework for Computing Effect Sizes and Meta-Analysis

Effect sizes were estimated using the  $r$  statistic based on means and variances and the number of participants or, alternatively, the  $F$  or  $t$  test values and degrees of freedom (see Rosenthal, 1984; Rosenthal & DiMatteo, 2001). The  $I^2$  statistic was used for assessing heterogeneity across studies. If only sample size and  $p$  value were reported by the authors of a study, we calculated a conservative estimate of effect size by converting the  $p$  values to the corresponding standard normal deviate equivalent and dividing the  $z$  score by the square root of the sample size. If an effect was declared as “significant” without providing  $p$  values, or if a bar chart showed clearly nonoverlapping standard errors of the mean, an alpha level of  $p < .05$  was assumed. If a result was reported to

be nonsignificant without giving the test statistic or  $p$  value, the corresponding effect size was assumed to be zero.

Effect sizes were consistently computed in such way that positive values reflect a happy face advantage, that is, faster or more accurate recognition or detection of happy versus all other faces (angry, fearful, neutral, and so forth). If the study contrasted happy faces with multiple other expressions, an average of these effect sizes was computed and used in the analysis in order to maximize statistical power and reliability, and to ensure that the analyzed effect sizes were independent. It must be noted that one could at least in principle compute the effect sizes for all possible pairwise comparisons between expressions. We decided to use the happy faces as the reference expression given that (a) our theoretical focus was specifically on the happy face advantage, (b) happy expressions were included in most expression recognition studies, and (c) practically all visual search studies with schematic faces (and a majority of those using photographic faces) contrasted the detection of threatening versus happy faces. Consequently, this conceptualization provided a straightforward access for testing our key hypothesis while maximizing the brevity of the data that could be incorporated in the meta-analysis.

Subsequently, weighted effect sizes were computed and subjected to meta-analysis using random effects model, yielding mean and 95% confidence intervals (CIs) for the effect sizes. This model assumes that effect sizes are contingent on study parameters, allowing for an estimation of both within and between studies variances. This approach is therefore well-suited for analyses where studies vary with respect to methodological aspects. Analyses involving moderator variables were also conducted using a fully random effects model.

It should, nevertheless, be noted that such statistical methods for calculating effect sizes rely on procedures that assume normality in the original population. Because tests of normality assumption were not routinely reported in the targeted studies, our analysis is based on the assumption that tested distributions stem from normally distributed populations. Although not being a serious threat, violation of the assumption of normality in the original data may affect our results. Also, intercorrelations between the dependent measures in within-subject designs may bias the effect size calculations (Dunlap, Cortina, Vaslow, & Burke, 1996). Because practically none of the reviewed studies reported sufficient raw data for computing this type of analysis, and estimating an “educated guess” for such a correlation across multiple dependent variables and conditions is inherently problematic, some caution should be warranted when interpreting the results. Finally, even though it is considered optimal to analyze only one effect size per study to ensure independence across effects, we computed multiple effect sizes (e.g., separate effect sizes for upright and inverted faces) for some studies to have sufficient power in the more detailed moderator analyses. The main results (see below) remain unchanged even when strictly one effect size per experiment was included in the analyses.

**Computing effect sizes for recognition studies.** For recognition studies, effect sizes were computed for the dependent variables of *recognition accuracy* and *recognition speed*. If frequencies (or proportions) were presented but not compared directly, we computed the proportions in pairwise manner assuming an equal frequency in responses and then computed the corresponding effect size. It must be noted that this method yields very conser-

vative estimates. If direct between-expressions contrasts were not reported but values in tables enabled estimating them (i.e., means and standard errors), we first estimated the  $t$  statistic and then computed the effect size on the basis of the  $t$  score and degrees of freedom. The happy face advantage was estimated in each reviewed study by computing separate effect sizes for the dependent measure (e.g., reaction time [RT]) between happy faces and each other facial expression tested in the experiment. In multifactor designs where expression was orthogonally crossed with other factors (such as gender), effect sizes were computed on the basis of the main effect of expression if no interactions were present. If there were interactions, the effect size was calculated on the basis of the planned comparisons or post hoc tests. If happy face recognition was compared against multiple facial expressions (i.e., angry, fearful, neutral etc.), a mean effect size for happy against all other expressions was computed as analyzing data by expression would have yielded low power due to differences across studies. This yielded a total of 41 effect sizes for recognition accuracy and 25 for recognition speed.

**Computing effect sizes for visual search studies.** For visual search studies, effect sizes were computed for the dependent variables of *detection speed difference* for happy versus each nonhappy face and *search slope difference* for happy versus each nonhappy expression. As some studies presented target happy faces among emotional distractors, and others among neutral distractors, effect sizes were computed separately for these two conditions. If both saccade latencies and manual response times (RTs) were reported in studies using eye tracking, RT data were analyzed for the sake of consistency. If multiple effect size indices (i.e., response latencies and slopes) could be computed, these were averaged to obtain a mean effect size. Otherwise, the analysis of effect sizes variable by variable would not have yielded sufficient power, given the differences in experimental design and analysis strategies across studies. This resulted in a total of 125 effect sizes (42 for photographic stimuli, 57 for schematic faces, and 26 for smiley faces).

**Moderator variables.** For all the studies, the following moderator variables were encoded for the data (see Table 1): stimulus type used (photographs, schematic faces, smileys) and presentation of stimuli (upright, inverted, eyes only, mouth only, reduced, scrambled, or “controlled”), the latter referring to stimuli where potential visual confounds would be controlled for (see Discussion). For studies using photographic faces, we also coded the stimulus set used (Ekman & Friesen, 1976; JACFEE, KDEF, and NimSTIM; due to low frequency, all other databases were pooled together as category “other”) to test whether possible recognition advantage holds over different facial identities and expression configurations throughout the sets. For recognition studies, we also coded how many expression categories (2–7) were included in the recognition task. Faces were considered as *photographic* if they consisted of real digitized color or black-and-white photographs of individuals with at least moderate dynamic range (e.g., 255 grey-scale levels).

Faces were considered as *schematic* if they consisted of either simple or complex line drawings depicting the major physiognomic changes associated with expressions (mouth, eye, and eyebrow shapes and positions), or significantly filtered or flattened photographic faces so that the natural dynamic range of the photographs was no longer present. Faces were considered as *smileys*

if the only expressive change across expressions was the shape of the mouth region. Although it is questionable whether such symbols convey genuine discrete emotions or even positive versus negative emotional valence, we refer to them consistently as happy (upturned mouth arc), angry (downturned mouth arc), and neutral (flat horizontal mouth arc). Regarding presentation condition, *upright* and *inverted* simply refer to the spatial orientation of the stimulus. *Eyes* and *mouths* conditions refer to stimuli where only the corresponding expressive cues were presented while masking or removing other aspects of the face, and *reduced* refers to faces whose some internal or external features were removed. *Scrambled* condition consists of faces whose internal features have been jumbled, for example, by rearranging the internal features or by “thatcherizing” the orientations of the face and its features. Figure 1 provides a summary of the stimulus types used in the original studies.

**File drawer analysis.** Nonsignificant results stand little chance of being published; thus, the present sample of studies might not comprise a random sample of all facial expression recognition and search studies conducted. Therefore, we conducted a file drawer using the *fail-safe N* analysis to estimate whether the present results were robust against the file drawer problem. We estimated  $N$  of null effects required to raise the combined significance level above 0.05. This is a conservative method for a file drawer analysis as null effects are defined as an effect size of zero, which is seldom the case in real life (Rosenthal, 1995).

## Results

### Expression Recognition

An overview of the results is presented in Table 2 and Figure 2. Mean recognition time and accuracy scores indicate that happy faces are categorized significantly faster than any other expression, with over a 200-ms advantage relative to the second fastest category (neutral followed by angry faces). Meta-analytic techniques confirmed a clear happy face advantage for both accuracy (mean weighted  $r = .34$ ) and speed (mean weighted  $r = .40$ ), with large effect sizes with CIs not containing zero, thus suggesting reliable happy face advantages at the population level. Recognition accuracy and speed of different expressions extracted from the original studies were also significantly correlated,  $r = .91$   $p < .05$ . Moderator analysis failed to establish an effect of to-be-recognized expression categories for either accuracy or speed ( $ps > .58$ ). Positive effect sizes not overlapping with zero were observed for both speed and accuracy for photographic and cartoon/smiley face stimuli, with no significant differences between the stimulus types in accuracy ( $p = .26$ ), but larger effect sizes for recognition speed of photographic versus cartoon/smiley faces ( $p = .04$ ). The moderator analyses did not reveal an effect of photographic stimulus database for neither speed nor accuracy ( $ps > .08$ ). Similarly, face orientation did not significantly modulate recognition speed or accuracy advantage ( $ps > 0.27$ ). Finally, the file drawer analyses (see Table 2) suggested that  $N > 2,000$  would be needed to bring the observed effects over an alpha level of .05, thus suggesting that file drawer problems would not be a significant threat to the analysis.

Table 2

Means ( $M_r$ ) and 95% Confidence Intervals (CIs), Sample Sizes, and Number of Participants and Studies Included in the Meta-analysis, and File Drawer Estimates Based on Fail-Safe  $N$  Method for Happy Face Processing Advantage in Recognition and Detection Studies

Variable	$M_r$	CI	Heterogeneity ( $I^2$ )	$N_{\text{participants}}$	$N_{\text{experiments}}$	Fail-safe $N$
Recognition speed	.40	.29 .51	76.99%	843	25	2,266
Recognition accuracy	.34	.25 .42	86.58%	3,561	41	6,830
Detection of photographic faces	.21	.07 .34	90.85%	976	42	2,898
Detection of schematic faces	-.52	-.60 -.45	87.05%	1,152	57	34,146
Detection of smiley faces	-.49	-.72 -.26	98%	327	26	8,485

Note. None of the CIs overlaps with zero.

### Expression Detection in Visual Search

For expression detection, a more complex pattern of results emerged. When all the data were analyzed together, a clear angry face advantage was observed with a mean weighted effect size of  $r = -.26$ . The CI for this effect size did not overlap with zero, thus suggesting an overall advantage for nonhappy (typically threatening) expressions across studies. However, moderator analyses revealed a significant effect of stimulus type ( $p < .001$ ) with more negative effect sizes and thus a larger angry detection advantage for schematic and smiley faces than for photographic faces. Follow-up analysis revealed that a happy face advantage was found for photographic faces (mean weighted  $r = .21$ ), whereas negative effect sizes and thus an opposite *angry face advantage* appeared for the schematic (mean weighted  $r = -.52$ ; Figure) and smiley (mean weighted  $r = -.49$ ) faces, with none of the effect sizes CIs overlapping with zero.

Further analysis of the schematic and smiley faces conditions revealed that the advantage toward nonhappy expression was insensitive to stimulus manipulations: Even the scrambled and the inverted faces led to significant detection advantages of the nonhappy faces, with CIs not overlapping with zero (schematic:  $r = -0.46$ ,  $CI = [-0.72, -0.21]$ , smileys:  $r = -.69$ ,  $CI = [-0.82, -0.56]$ ). Critically, these effect sizes were statistically indistinguishable from the upright versus scrambled/inverted faces for either the smiley or the schematic face condition ( $ps > .05$ ). Again, file drawer estimates (Table 2) suggested

$Ns > 2,000$  would be needed to bring the observed effects over an alpha level of 0.05, providing no clear evidence of file drawer problems.

Even though our main contrast of interest was concerned with detection of happy vs. nonhappy facial expressions, we also conducted as secondary analysis for the effect sizes in the happy vs. angry face detection comparison: Because particularly the angry faces have been proposed to enjoy a biologically driven threat detection advantage (e.g., Lundqvist, Esteves, & Öhman, 1999), the happy-vs.-other-faces contrast could effectively dilute this specific effect. These results nevertheless paralleled those of the main analysis with a clear angry face advantage ( $r = -.27$ ,  $CI = [-0.37, -0.17]$ ) that was again modulated by the stimulus type ( $p < .001$ ).

### Discussion

The *recognition* advantage of happy faces over the other basic expressions of emotion is a reliable psychological phenomenon supported by the affective uniqueness (and possibly diagnostic value) of the happy faces. The advantage can be observed irrespective of stimulus type and task conditions, even though the effect is more pronounced with photographic than with schematic/smiley faces. On the contrary, the *detection* advantage for happy faces was found to be sensitive to methodological variables in the experimental design, mainly, stimulus type. At a general level, the meta-analysis of visual search studies suggests an advantage for

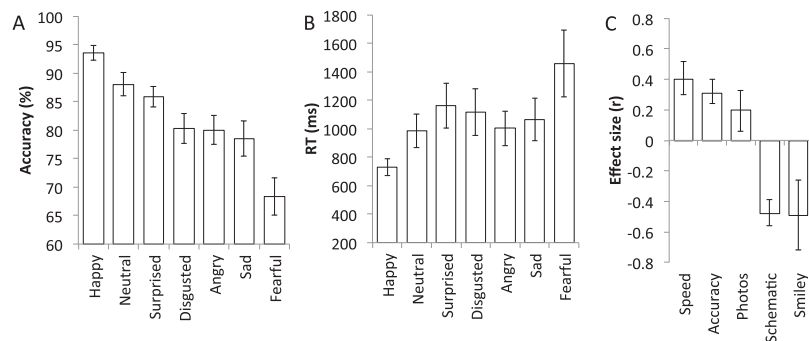


Figure 2. Means and confidence intervals for latencies (A) and accuracies (B) in facial expression recognition studies, and mean effect sizes in different types of recognition and visual search studies (C). Note. In C: Speed = Effect size for recognition latency; Accuracy = Effect size for recognition accuracy; Photos, Schematic, and Smiley = Effect size for visual search with photographic, schematic, and smiley faces, respectively. Bars above or below zero indicate a happy or an angry face advantage, respectively.

nonhappy (typically, angry) expressions, with happy faces being detected more slowly or with shallower slopes than nonhappy faces. However, moderator analyses revealed a disadvantage for happy faces only for artificial schematic and smiley stimuli whereas more realistic photographic faces led to the opposite, happy face advantage. Consequently, this synthesis challenges the assumption of an advantage in detecting negative, or angry, facial expressions. With realistic facial stimuli, there is a consistently better recognition and detection of happy expressions.

### Mechanisms Underlying the Happy Expression Recognition Advantage

The reviewed data suggest conclusively that the happy face recognition superiority is a genuine psychological effect associated with the expressive category of the face. The large mean effect sizes for both accuracy and speed confirm that happy facial expressions are recognized faster and more accurately than any other expression. Although the present data do not allow us to disentangle all the mechanisms underlying this effect, the meta-analysis can clarify the possible hypotheses that have been suggested to explain the happy face advantage in expression recognition. The main hypotheses that we put forward in the introduction are concerned with (a) the affective uniqueness, (b) the diagnostic value of the happy faces, and (c) featural processing of happy expressions.

First, happy faces are the only “basic” expression that show positive affect; thus, their facilitated recognition could be explained by their unique affective value. On the contrary, all the other expressions—except surprise, which is affectively ambiguous—share negative affective valence, making them susceptible to mutual competition and interference during recognition (Mendolia, 2007). If so, the happy face advantage should increase in magnitude when the number of to-be recognized negative expression categories—and consequently their mutual interference—would increase in experimental designs. However, the meta-analysis does not support this hypothesis. Moderator analysis did not reveal a statistically significant association between effect sizes and the number of to-be-recognized expression categories with only a slightly larger happy face advantage in studies involving a larger number of expressions. In the same vein, prior research has shown that the happy face advantage occurs in studies where only one positive and one negative expression category is used (Kirita & Endo, 1995; Leppänen & Hietanen, 2004) or when the design involves surprised expressions which are amenable to both a positive and negative interpretation (Calvo & Nummenmaa, 2009), producing reduced or minimal affective interference. Consequently, affective uniqueness probably does not significantly contribute to the happy face advantage. Nevertheless, positive affective valence of the happy faces probably plays some role because studies have shown that manipulation of the emotional valence of the environment by pleasant versus unpleasant odors can modulate the happy face recognition advantage (Leppänen & Hietanen, 2003). Because people typically report being moderately happy most of the time (Diener & Diener, 1996), this compatibility between an individual’s mildly happy affective tone and the matching affective valence of the happy faces could facilitate recognition of happy expressions.

Second, it is possible that some visual features of the happy faces facilitate access to their affective meaning during the recognition process. The key candidate that has been put forward is the diagnostic value of visually salient facial features, especially the smile (Calvo et al., 2012; Calvo & Nummenmaa, 2008; Calvo et al., 2010). The meta-analysis provided some support for this hypothesis. The happy face advantage was observed consistently for all employed stimulus types, including photographs from different stimulus sets, cartoon faces, and even schematic smiley faces. Actually, only six of the reviewed recognition accuracy experiments showed zero or negative effect sizes. Happy face advantage is observed similarly for upright and inverted faces, suggesting that featural processing of the diagnostic value of the smiles plays a key role in facilitated recognition of happy expressions (see, e.g., Calvo et al., 2010). However, this effect is not critically dependent on the visual properties of the stimuli, as the happy expressions are recognized equally well from different facial expression datasets, as well as from schematic faces where angry and happy faces contain an equal amount of expressive information.

Even though saliency of the mouth region could partially explain the facilitated recognition of photographic faces by focusing the observers’ attention to the mouth, which is the most diagnostic feature of facial happiness (Calvo & Nummenmaa, 2008), it cannot completely explain why recognition of the smiley faces would be facilitated as well. However, it must be noted that photographic faces lead to larger effect sizes for recognition speed than schematic or cartoon faces ( $p = .05$ ; see also happy face detection advantage for photographic faces). Because the saliency of the mouth region is higher in photographic relative to schematic smiling faces (Calvo & Nummenmaa, 2008), it is possible that the visual conspicuity hypothesis might support recognition advantage for photographic but not for schematic faces. Thus, happy faces are in general processed most efficiently (as indexed by almost uniformly positive effect sizes), yet the more natural photographic faces further boost the advantage.

There is also a third possible explanation that cannot be addressed by the present meta-analytic investigation. Namely, the frequency-of-occurrence hypothesis predicts that happy faces are recognized best because they are encountered most often in everyday life. A qualitative synthesis of the literature nevertheless suggests that this hypothesis could partially account for the happy face recognition advantage. Specifically, in retrospective ratings people report that they encounter happy faces in daily life more often than any other expression. (Somerville & Whalen, 2006). In line with this, the actual frequency with which different expressions are observed in daily life is negatively correlated with recognition speed response latencies in laboratory studies, with happy faces being the most often encountered in social settings and the most quickly recognized expressions (Calvo et al., 2014). Consequently, repeated exposure to different exemplars of happiness could tune the visual system for efficient recognition of happy faces. The frequent exposure to facial happiness could also strengthen the link between the semantic category of “happiness” and the related expressive signals, including the visually reduced or purely symbolic expressions such as those of the smiley faces. This is in line with research on the in-group advantage in facial expression recognition: Individuals are more accurate in judging the emotional expression of in-group versus out-group members (Elfenbein & Ambady, 2002), suggesting that familiarity of the



visual emotional signals plays an important role in shaping their recognition process. In sum, although the existing studies seem to suggest that frequency of occurrence may facilitate the happy face advantage, future studies need to establish its possible unique contribution to happy face recognition.

### When Happy Face Detection Advantage Becomes a Detection Disadvantage

In contrast with the evidence showing a consistent happy face advantage in expression recognition, no such effect was found in the omnibus random effects model for visual search studies. Instead, when all the studies were considered together, results revealed a detection disadvantage for happy versus other—typically, angry—faces, which is in line with earlier narrative reviews (Frischen et al., 2008). However, moderator analyses revealed that this superiority toward nonhappy expressions was restricted to the artificial, symbol-like schematic and smiley faces, whereas studies with photographic faces showed a happy face superiority in accordance with the recognition studies reviewed above. Unlike in expression recognition tasks, photographic and schematic facial stimuli yielded completely different results when used as stimuli in visual search tasks. How can we reconcile these seemingly discrepant results from detection and recognition studies? There are two alternatives, which are also related to the *emotional* and *perceptual* hypotheses of attentional capture by facial expressions outlined in the Introduction.

**Emotional versus perceptual accounts for expression detection advantage.** We can take the results of the omnibus meta-analysis on visual search studies at face value and conclude that the nonhappy face (threat) detection advantage is a genuine psychological phenomenon driven by automatic affective analysis and subsequent attentional capture. This would be in line with the emotional processing hypothesis: Such a model would assume that attentional capture by facial expression could bypass conscious expression recognition. Thus, facilitated *recognition* of happy expression would be flipped into facilitated *attentional detection* of angry faces if attentional orienting operates primarily at preattentive level preceding conscious recognition and favoring threat detection (Öhman, Lundqvist et al., 2001). This argument is supported by studies examining search slopes for different matrix sizes with search slopes being less steep for angry than for happy target faces, suggesting parallel and possibly preattentive search (Eastwood et al., 2001) and implying more efficient preattentive detection of angry faces. However, moderator analysis revealed that the happy face disadvantage was prominent only for schematic and smiley faces. It could be argued that photographic facial expression stimuli add visual noise to the task due to individual differences in physiognomy and expression kinematics, with greater variability for nonhappy than for happy faces (see Calvo & Nummenmaa, 2008). If so, this would give some way to a happy face detection advantage (rather than merely zero effect size) as was the case with photographic faces.

However, a closer inspection of the results from the moderator analysis actually lends more support to the *perceptual* hypothesis of attentional capture by emotional faces. *Visual saliency* refers to the perceptual prominence of an image (e.g., a face) or image region (e.g., the mouth) in relation to its surroundings and is defined in terms of a combination of physical image properties

such as luminance, contrast, color intensity, and spatial orientation (Borji & Itti, 2013; Torralba, Oliva, Castelhana, & Henderson, 2006). Saliency can be modeled by means of computational algorithms (Itti & Koch, 2001; Walther & Koch, 2006) that simulate the properties of a given image that attract attention in the visual system pathways from the retinal neurons via lateral geniculate nucleus (LGN) to the area primary visual cortex (V1) in the occipital cortex. Both human data and computational models suggest that salient objects are indeed prioritized in the early stages of attention deployment (Borji & Itti, 2013). With respect to photographic faces yielding a happy face advantage in visual search, similar computational modeling has established that visual search performance for facial expressions can be predicted by the visual conspicuity or physical saliency of the face stimuli: Response latencies are *fastest* to the happy expressions whose *visual saliency is also highest*, and there is time course correspondence between the saliency peak and the allocation of overt attention to the target face in a visual search array (Calvo & Nummenmaa, 2008). This accords with the view that emotional content plays only a minor role in attentional detection of photographic faces, and visual search would be primarily driven by visual rather than affective factors (Cave & Batty, 2006).

But how about the schematic faces, which are presumably better controlled with respect to visual features? Studies on visual search of objects and shapes have consistently found that perceptual discriminability between targets and distracters is a major determinant of detection performance (Duncan & Humphreys, 1989; Treisman & Gelade, 1980). It would initially seem odd that, for example, smiley faces with down-turned mouths would be more distinguishable from smiley faces with up-turned mouths than vice versa because only the target versus background stimulus status is reversed. However, the conspicuity of visual signals is contingent on more complex stimulus properties than mere mean luminosity. Computational modeling has actually confirmed that specific combinations of the low-level image metrics can also give rise to visual conspicuity even in schematic faces. Specifically, the spatial orientation of the mouth or the eyebrows, and their contrast in relation to the contour of the face, make the schematic angry faces more salient than the happy faces. Interestingly, the saliency values are again highest for the facial expressions that are detected fastest, that is, angry faces in the case of schematic expressions (Calvo & Nummenmaa, 2008).

In line with the perceptual hypothesis of expression detection, our meta-analysis confirmed that the nonhappy smiley and schematic faces keep on attracting attention even when their emotional features are removed or significantly reduced due to scrambling of the internal features or inversion of the face. This clearly points toward a visual rather than an affective explanation for the happy face detection disadvantage: Because nonhappy faces attract attention even when devoid of affect, their physical features are key candidates for driving the search performance. Consistently, a number of recent studies (Becker, Anderson et al., 2011; Coelho, Cloete, & Wallis, 2010; Horstmann, Becker, Bergmann, & Burghaus, 2010; Mak-Fan, Thompson, & Green, 2011) have experimentally confirmed the higher visual conspicuity of the schematic angry faces and suggested that the threat detection advantage in the visual search of schematic faces is not driven by affective factors: A threat detection advantage can even be observed when the schematic faces are made completely nonface-like and unex-

pressive by removal of the eyes and breaking the mouth line (Mak-Fan et al., 2011). Similarly, studies with nonhappy (here angry) faces with scrambled internal features and completely lacking emotion may yet lead to an “angry” face advantage. Moreover, denting the chin line of the angry faces, making it shaped like the angry mouth but unflattering the expressive features, abolishes the angry face advantage (Horstmann et al., 2010).

Consequently, the perceptual rather than the affective hypothesis provides the most parsimonious explanation for both the detection advantage of happy photographic faces and that of angry schematic faces: The advantage is reversed for photographic versus schematic faces, likely because relative visual conspicuity is highest for photographic happy faces whereas it is highest for schematic angry faces (see Calvo & Nummenmaa, 2008). Thus, whereas visual features varying across different types of happy faces (photographic, schematic and so forth; see above) lead only to minimal differences in recognizing the expressions, corresponding differences across happy face stimulus types lead to reliable differences in visual search performance. This occurs because unlike recognition, visual search is critically dependent on the *relative* visual conspicuity across the expression categories, and this relative conspicuity varies across different stimulus types. However, we note that there exists a limited amount of evidence for facilitated attention capture by angry schematic faces in anxious versus nonanxious participants during visual search (Eastwood et al., 2005). This suggests that motivational factors—hence involving affective processing—may also play some role in visual search performance. In line with this view, it has recently been shown that the arousal value of facial expressions modulates visual search performance, with high-arousal stimuli enjoying attentional prioritization (Lundqvist, Juth, & Öhman, 2013).

**Are physiognomic features confounds in the visual search task?** After the initial demonstration of the angry detection advantage with photographic faces (Hansen & Hansen, 1988), perceptual confounds were suggested as an explanation (Purcell et al., 1996). Subsequently, a number of research groups have proposed that using schematic faces should be an effective and strict way to control for visual confounds because these faces are composed of similar line elements, and angry faces can be made happy and vice versa just by flipping the eyebrows and the mouth upside down. This transformation of the facial elements (see Figure 1) was not presumed to influence visual conspicuity even though later computer simulations (Calvo & Nummenmaa, 2008) and empirical work (Becker, Anderson et al., 2011; Coelho et al., 2010; Horstmann et al., 2010; Mak-Fan et al., 2011) suggested that such claims are unwarranted. This raises concerns regarding the usability of extremely reduced samples of stimuli and prototypes in social research. This also serves as a reminder that simpler, more parsimonious explanations, such as visual discriminability in the case of visual search, should be carefully ruled out before making assumptions regarding higher-order semantic or affective mechanisms.

It must be borne in mind that detection of realistic faces also depends on their visual features and, especially, the visual saliency of the smiling mouth. Should we consider this feature also a “perceptual confound?” If the question pertains to whether affective features drive the attention capture by happy faces, the answer is obviously “yes” because the smiling mouth can facilitate attentional selection of the happy face in the absence of affective

processing. However, this leads to questions regarding the origins of such conspicuous facial features. In principle, there are two possible alternatives. The *affective detector hypothesis* posits that the visual system has been tuned to recognize specific phylogenetically significant visual features; thus, the development of the sensory systems would have been biased by the expressive repertoire of the species (Öhman, Lundqvist et al., 2001).

However, it is equally possible that the expressive repertoire of the human species has developed to capitalize on the principles of the visual system. Accordingly, the *perceptual bias hypothesis* states that the biologically most significant expressions would have evolved toward high visual conspicuity (Horstmann & Ansgor, 2009; Horstmann & Bauland, 2006). It is difficult to provide strong evidence that could clearly favor either of the hypotheses, and they may even be complementary to each other: It has also been proposed that coevolution has shaped both the facial expressions *and* the visual system to work effectively in tandem to facilitate recognition of specific expressions (Becker & Srinivasan, 2014). But no matter how the smile has evolved, swift processing of facial signals indicating pleasurable and beneficial social interactions may be, after all, more important to our species than rapid detection of relatively infrequent threats posed by others (e.g., physical harm, distress, and intoxication) in the social environment (Calvo et al., 2014).

**Do emotional features contribute to detection of facial expressions?** We intentionally restricted our review on the visual search task, given that this has been the standard test for the widely assumed hypothesis regarding the threat detection advantage (see Frischen et al., 2008). Consequently, the present data do not undermine or contradict the facilitated processing of and orienting to other types of emotional signals (Vuilleumier, 2005), and numerous studies with appropriate perceptual controls have consistently demonstrated a clear bias toward emotional signals using visual scene (Calvo, Nummenmaa, & Hyönä, 2008; Nummenmaa et al., 2006; Nummenmaa, Hyönä, & Calvo, 2009) and auditory (Brosch, Grandjean, Sander, & Scherer, 2008) stimuli. Particularly strong evidence comes from studies where initially neutral abstract shapes associated with rewards and punishments via Pavlovian conditioning (thus devoid of visual confounds) have been confirmed to bias attentional selection (Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes, 2011; Pool, Brosch, Delplanque, & Sander, 2014; Schmidt, Belopolsky, & Theeuwes, 2014).

It is also possible that both visual and emotional factors have additive or interactive bottom-up effects on attentional orienting toward facial expressions as well, yet the present evidence for genuine emotion-driven attention capture by happy or nonhappy faces in the visual search task is weak. The findings of this meta-analysis actually suggest that the visual search task with different facial expressions might not be very well-suited for addressing the effects of emotion on attentional processing in the first place. Visual search is a highly contextualized process, and the similarity (be it affective or visual) between the target and distractors is a major determinant of search performance (Duncan & Humphreys, 1989; Treisman & Gelade, 1980). Thus, unless the search context and targets are carefully controlled, the mere detection advantage for a single target type is not very informative of the underlying neurocognitive mechanisms bringing about the advantage. Because the stimulus categories used for testing an

emotionality bias are inherently associated with different visual properties such as contrast, complexity, and visual saliency, clear inferences on the key questions related to emotional and visual conspicuity become difficult to tackle.

By moving beyond the confounds and methodological challenges underlined by the present meta-analysis, it is possible that the visual search paradigm could significantly contribute to studying emotional attention toward faces in the future. For example, conditioning paradigms could be used for associating initially emotionally neutral (and visually matched) faces with different hedonic values. Concurrent manipulations of the visual conspicuity of the faces would provide an elegant way of teasing apart the contributions of visual and emotional saliency of the stimuli.

## Conclusions

In sum, the current meta-analysis revealed an advantage for both the recognition and detection of happy facial expressions in real (photographic) faces. In contrast, there exists a detection advantage of nonhappy (typically, angry) expressions in schematic and smiley faces. The recognition advantage in expression categorization tasks reflects efficient processing of happy faces due to their diagnostic value. The contribution of other possible factors such as high frequency of seeing happy faces in everyday life needs to be validated in future studies. In contrast, the detection advantage in visual search tasks depends on stimulus type and suggests that visual factors drive the mechanisms underlying facilitated expression detection. The data stemming from visual search studies do not support the widely accepted claim that an advantageous detection of angry (or happy) faces would be due to processing of their emotional value. The conclusions of the present review are consistent with what was originally proposed by Treisman and Gelade (1980): Conspicuous visual objects are prone to capture attention and drive search and detection mainly, if not only, as a function of physical stimulus differences. The current review may settle down the debate regarding the nature of the facilitated detection of certain facial expressions in the face-in-the-crowd visual search task, and point toward experimental approaches where effects of emotion and low-level visual features can be better controlled for.

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Received January 28, 2014

Revision received November 1, 2014

Accepted November 6, 2014 ■