Looking at the eyes of happiness: Positive emotions mediate the influence of life satisfaction on attention to happy faces

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Despite significant advancements in the research of subjective well-being (SWB), little is known about its connection with basic cognitive processes. The present study explores the association between selective attention to emotional stimuli (i.e. emotional faces) and both the emotional and cognitive components of SWB (i.e. emotional well-being and satisfaction in life, respectively). Participants (N = 83) were asked to freely watch a series of 84 pairs of emotional (happy, angry, or sad) and neutral faces from the Karolinska Directed Emotional Faces database. Eye-tracking methodology measured first fixations, number of fixations, and the time spent looking at emotional faces. Results showed that both the emotional and cognitive components of SWB were related to a general bias to attend to happy faces and avoid sad faces. Yet, bootstrapping analyses showed that positive emotions, rather than life satisfaction, were responsible for the positive information-processing bias. We discuss the potential functionality of these biases and their implications for research on positive emotions.

Keywords: attention; life satisfaction; positive mood; subjective well-being; eye tracking; cognition; cognitive bias; selective attention; positive emotions

Among researchers of psychological well-being, there is consensus on the need to distinguish between emotional and cognitive elements. This distinction is fully captured in the concept of subjective well-being (SWB) which includes both the current emotional state and the more abstract evaluation of the degree of satisfaction with life (Diener, 1984). Research has shown that these two components are psychometrically distinct (Diener, Suh, Lucas, & Smith, 1999) and are associated with different variables and outcomes. Whereas emotional states are more closely linked with daily events and circumstances (Diener, Kahneman, Tov, & Arora, 2010), life satisfaction (LS) correlates closely with more stable factors, such as personal achievement, personal education level, and national or personal wealth (Schimmack & Oishi, 2005).

A number of factors are associated with SWB. A burgeoning literature has demonstrated that psychological variables (e.g. personality, goals, expectations, or beliefs), physical health, and demographic and socioeconomic factors are associated with both positive emotions (Isen, 2004; Lyubomirsky, King, & Diener, 2005) and LS (Diener, 2009; Helliwell & Putnam, 2004). However, less is known about the cognitive mechanisms that underlie well-being. Existing research on these mechanisms has typically followed the general idea of a congruency effect by which particular mood states (e.g. happiness or depression) are associated with a preference and/or facilitation to process information with a specific valence (e.g. positive and negative stimuli) (Bower, 1981). Within this framework, positive mood has been shown to have an effect on memory (Matt, Vázquez, & Campbell, 1992; Ashby, Isen, & Turken, 1999), decision-making (Isen, 2002), the facilitation of global vs. local processing styles (Fredrickson & Branigan, 2005; Gable & Harmon-Jones, 2010), and visuospatial attention (Rowe, Hirsh, & Anderson, 2007).

The literature on the relationship between SWB and mechanisms of selective attention is even scarcer compared to that of other psychological processes. Selective attention is particularly relevant, as it is one of the main mechanisms by which people filter information by paying attention to some stimuli at the expense of others (Isaacowitz, 2006). Unfortunately, much of the evidence of the relationship between well-being and selective attention has been from studies of mood (Bistricky, Ingram, & Atchley, 2011; Epp, Dobson, Dozois, & Frewen, 2012; Peckham, McHugh, & Otto, 2010) and anxiety disorders (Bar-Haim, Lamy, Per Flem, Bakermans-Kranenburg, & van IJzendoorn, 2007; Frewen, Dozois, Joanisse, & Neufeld, 2008; Armstrong & Olatunji, 2012), rather than those of psychological well-being. In a mood-congruency framework, it is expected that attentional biases operate in opposition for...
negative and positive moods; however, the relationship between positive emotions and attention has not yet been systematically explored (Fredrickson, 2001). As Tamir and Robinson (2007) have noted, it is surprising that systematic research on the relationship between pathological moods and attentional processes has not been paralleled by research on positive emotions.

Despite the paucity of studies on basic attentional processes and well-being, some studies have investigated the association between positive emotions and selective attention towards emotional materials. Dot-probe and emotional Stroop paradigms have been frequently used in these studies to explore attentional biases. In a standard dot-probe task, an emotional stimulus and a neutral stimulus (which can be either words or images) are presented simultaneously in two different parts of a computer screen. This presentation is replaced by a spatial probe, such as a dot, which appears in the area of one of the two previous stimuli. Participants have been found to be quicker to respond to the probe stimulus when it is presented in the attended, rather than unattended, area of the visual display (MacLeod, Mathews, & Tata, 1986). In the emotional Stroop task, participants are asked to name the colors in which words are written. Reaction time (RT) has been found to be slower when the content of the words is congruent with participants’ moods, providing an indication of the stimuli to which they attended. Early evidence of the role of positive mood in selective attention towards emotional information came from a series of studies by Tamir and Robinson (2007). The authors found that participants with positive moods, whether natural or induced, showed a consistent preference to process positive words in dot-probe tasks. That is, RT was faster for probes preceded by positive words than for probes preceded by negative words. However, Mauer and Borkenau (2007) found that higher scores of approach temperament, a psychometrically derived factor contingent upon positive emotions, were not associated with performance in versions of the Stroop task that used words or emotional faces. Also using an emotional Stroop paradigm, Segerstrom (2001) found that optimistic individuals showed more interference in processing positive vs. negative words, which is typically interpreted as an increased preference toward processing positive information.

Although the relationship between positive emotional SWB components and cognitive processes has received some attention, similar research on LS is nearly nonexistent. This is somewhat paradoxical, as there is a general agreement that judgments of LS are also cognitive in nature (Diener, Emmons, Larsen, & Griffin, 1985; Schimmack, Schupp, & Wagner, 2008). Although evidence has suggested that memory biases and heuristics (e.g. the availability of positive vs. negative memories) may affect evaluations of LS (Fox & Kahneman, 1992), it could also be possible that overall assessments of one’s own life are grounded upon basic perceptual or attentional mechanisms. A congruency relationship between stable LS and emotional processing, similar to the mood congruency hypothesis, has been proposed (Cummins & Nistico, 2002). According to this notion, individuals selectively attend to, retrieve, and reconstruct events so that they are consistent with their overall LS estimations, which in turn promote and maintain LS. One of the few studies investigating these relationships found that participants with higher LS scores were faster in detecting a schematic smiling face among an array of neutral faces and spent more time looking at happy rather than sad faces (Vittersø, Oelmann, & Wang, 2009).

Although results derived from studies of RT (e.g. dot-probe, Stroop test, or detection of selected targets) support the idea that positive attentional biases are related to positive affect (Grafton, Ang, & MacLeod, 2012), the evidence is equivocal. These paradigms are problematic as they are unable to provide information on real-time attentional patterns (Teachman, Joormann, Steinman, & Gotlib, 2012) and are conceptually vague (Koster, Crombez, Verschuer, & De Houwer, 2004; Schmukle, 2005). Therefore, despite some evidence that positive mood states bias attention toward positively valenced stimuli, more robust research using methods that allow for the detection of real-time processes is needed (Armstrong & Olatunji, 2012).

Another relevant issue in the research of cognitive mechanisms and well-being that must be considered is the interplay between cognitive and emotional components of SWB in relation to such mechanisms. As some authors have theorized, it seems plausible that stable psychological factors may influence emotional processing through temporary mood states (Rusting & DeHart, 2000). According to this idea, overall LS may be involved in the selection of behaviors that maximize the frequency of positive mood states which in turn increase the processing of positive information at the expense of negative information. This mediation model is promising and consistent with mood-congruency theories. As long as LS predisposes individuals to experience-related emotional states (Gamble & Gärbling, 2012), these states may account for the relationship between rather stable judgments of LS and the processing of emotional stimuli. However, to the best of our knowledge, no previous studies have assessed the contribution of LS and positive mood states on attentional processing of emotional information. In summary, the aim of this study is to investigate the relationship between components of SWB and selective attention to facial expressions as emotional stimuli using eye-tracking methodology. The analysis of gaze patterns with this approach allows us to overcome the methodological and conceptual problems inherent in RT-based paradigms such as the dot-probe and emotional
Stroop tasks. Eye tracking enables the recording of sequential movements in real-time as stimuli are presented, thus providing a reliable index of selective attention (Calvo & Avero, 2005). Another advantage of this methodology is that it allows for precision in comparing across the processing stages involved (e.g. early vs. late components). For any given trial, visual scan analyses provide information on the probability of having a first fixation on a given face (which is related to early stages of processing) in addition to information on the total number of fixations and the total time spent on a given face (which is related to later stages of processing) (Armstrong & Olatunji, 2012).

A previous study that employed similar methods found that more optimistic university students were significantly less likely to look at images of skin cancer compared to neutral stimuli, such as line drawings and neutral faces, suggesting that optimists wear ‘rose-colored glasses’ (Isaacowitz, 2005, p. 407). Interestingly, this effect of selective inattention remained significant even after controlling for neuroticism, positive and negative affect, and depressive symptoms.

The use of emotional faces to study selective attention processes seems particularly appropriate, as facial expressions convey a wealth of social and emotional information (Gross, 2005) and automatically elicit emotional and behavioral reactions in observers (Anderson, Siegel, White, & Barrett, 2012; Aviezer, Bentin, Dudarev, & Hassin, 2011; Wieser & Brosch, 2012). The processing of emotional faces is also based on relatively well-known brain circuitry, which links this type of research to the field of neuroscience and could potentially serve as biomarkers of several mood and psychological disorders (Isaac, 2012). Emotional facial expressions have been used in studies of attentional biases in depression (Bistricky et al., 2011) and anxiety (Staugaard, 2010). Moreover, there are databases available with normative data on relevant features of emotional faces, including intensity, valence, and arousal (Lunqvist, Flykt, & Öhman, 1998; Tottenham et al., 2009).

Based on previous studies of the selection of positive information associated with positive mood (i.e. a mood-congruency framework), we hypothesized that a positive emotional state component of SWB would be associated with a higher likelihood of processing happy faces and a lower likelihood of processing negative faces manifested through first fixations, number of fixations, and total time attending to these faces. Although research on cognitive processes related to LS is scarce, we predicted a similar relationship as the one found for the emotional component of SWB, according to previous research by Vittersø et al. (2009). Finally, we tested the interplay between cognitive and emotional SWB components in predicting attentional processing of emotional information through bootstrapping analyses.

Method

Participants
A sample of 83 undergraduate students received course credits for their participation in the study. The group consisted of 12 men and 71 women, with a mean age of 22.23 years (SD = 2.64). All participants had normal or corrected-to-normal vision and were allowed to wear their glasses or contact lenses as required.

Questionnaires

Positive and negative mood states
Two numeric scales, one to assess positive mood states and the other negative, were delivered prior to the attention task. Each scale was comprised of four items. Items on the positive mood scale included happy, optimistic, joyful, and content. Items on the negative mood scale included melancholic, depressed, upset, and sad. Each item consisted of an end-point labeled numeric scale consisting of numbers, from 0 to 10, with the end points labeled with a verbal referent (0 = Not at all, and 10 = Very much), on which participants indicated how they felt upon administration of the questionnaires by selecting one of the response options. The total score ranged from 0 to 40 for each scale. In the current study, internal consistency for both positive and negative mood scales was good (α = 0.86 in both cases).

Life satisfaction (LS)
Participants completed the Satisfaction with Life Scale (SWLS), a 5-item self-report measure to assess LS (Diener et al., 1985). Respondents indicated their agreement with each item on a scale ranging from 1 (strongly disagree) to 7 (strongly agree). SWLS total scores range from 5 to 35. This measure has shown excellent reliability and validity (Pavot & Diener, 1993). In the current study, internal consistency was good (α = 0.89).

Attention task

Overview
The attention task was delivered after consent was obtained and the SWLS and mood scales were completed. These measures were completed immediately before the start of the attention task. In this task, participants were asked to freely view emotional and neutral information. After a central fixation cross on the computer screen was displayed, a secondary numeric task was performed to maintain that central fixation. Pairs of stimuli were then presented, with one item located on the left of the central fixation point and the other on the right. Stimulus pairs were images of an emotional (either happy, angry, or sad) and a neutral facial expression...
made by the same actor. Eye tracking monitored and registered participants’ gaze behavior during the presentation of the stimulus.

**Stimulus materials**

Stimuli consisted of pairs of images of an emotional and a neutral facial expression made by the same actor. Faces were selected from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998). Following the procedures used by Williams, Moss, Bradshaw, and Mattingley (2005) and Calvo and Lundqvist (2008), original KDEF frontal view pictures were fit within an oval window. Surrounding parts of the images, including the hair and neck, were darkened to remove non-informative aspects of the faces.

Stimuli selection was based on two parameters: the emotional discreteness of faces for the corresponding emotion and their intensity ratings. The selection was made according to a validation study of the images in the KDEF database (Sanchez & Vazquez, 2013). Based on these norms, 28 happy, angry, and sad expressions, together with corresponding neutral expressions, were selected as stimuli for the current study. Each category of emotional expressions was comprised of 14 males and 14 females.

**Experimental design**

The attention task consisted of 84 trials (28 for each category of happy, angry, and sad expressions) paired with the corresponding neutral expression. Trials were randomized for each participant. Emotional and neutral expressions were presented equally as often on the left and on the right side of the screen. Six practice trials preceded the presentation of the actual trials, which began after a brief pause.

A beam projector displayed stimuli onto a 147 cm by 110 cm screen. The size of each face was 21 cm by 27 cm. Pictures were centered on the screen and 42 cm apart as measured from their centers. Participants were seated approximately 226 cm from the screen’s center, resulting in a visual angle of approximately 5.5° between each picture’s center and the screen’s center.

Each trial began with a black screen for 500 ms and was followed by the display of a white fixation cross in the middle of the black screen for another 500 ms. Participants were instructed to fixate their gaze on the cross, which was then replaced by a random one digit number ranging from 1 to 9 for 1000 ms. Participants were asked to fixate on and identify the number in order to record response times. This procedure has been previously used by Calvo and Avero (2005) to ensure that participants were focused on the center of the screen before the stimulus pairs appeared. Immediately after the offset of the one digit number, a pair of faces (either happy-neutral, angry-neutral, or sad-neutral) was presented for 3500 ms and participants were allowed to freely watch the screen without constraints until the onset of the next trial, which was demarcated by the appearance of the next fixation cross (see Figure 1). Free observation of image pairs was implemented to encourage naturalistic information processing (Isaacowitz, 2005).

**Eye-tracking device**

Participants’ eye movements were recorded using an ASL 504 eye-tracker system from Applied Science Laboratories. This system employs a Pupil-Centre Corneal Reflection method (Mason, 1969). An infrared light is projected over the participant’s eyes and the gaze position at any given time is calculated by tracking the reflections of the light source from the pupil in conjunction with the reflections from the cornea.

This system provides 60 Hz measures of eye-gaze coordinates (i.e. an estimation of coordinates every 16.7 ms). Stimuli presentation was controlled by National Instruments software and was automatically synchronized with the eye-tracking system at the beginning of each trial. Participants were seated in an anatomic chair to keep their head position stable, comfortable, and to maintain a distance of approximately 60 cm between their eyes and the eye tracker. Eye movement signals were converted to visual fixation data with Eyenal software. Visual fixations were defined as lasting a minimum duration of 100 ms and having a maximum fixation radius of 1 degree.

**Selective attention indices**

Fixation data recorded with the eye tracker during the 3500 ms period were used to estimate three indices of selective attention components employed in previous research (Kellough, Beevers, Ellis, & Wells, 2008): initial orientation, fixation frequency, and fixation time.

Initial orientation refers to the probability of recording a fixation to an emotional expression following the onset of expressions, reflecting tendencies of initial attention to focus on emotional information. Initial orientation indices were estimated for each emotional picture condition (i.e. happy-neutral, angry-neutral, and sad-neutral) by calculating the number of trials in which eye movements were initially directed towards the emotional face as a proportion of the number of trials for that given emotional condition (see Caseras, Garner, Bradley, & Mogg, 2007).

Fixation frequency refers to the numbers of times participants direct and redirect their gaze to an emotional face during the 3500 ms period, reflecting the proportion of fixations made to emotional information. Fixation
frequency for each emotional picture condition was indexed as the mean proportion of fixations to the given emotional face, by computing the number of fixations to that type of emotional face divided by the total number of fixations to both emotional and neutral faces across the corresponding trials.

Lastly, fixation time refers to the total time that participants fixate on an emotional face during the 3500 ms period, reflecting the proportion of time that participants devote to emotional information during the trial. Fixation time for each emotional picture condition was indexed as the mean proportion of time fixating to the given emotional face divided by the total duration of fixations to both emotional and neutral faces across the corresponding trials.

Thus, selective attention indices for all the attention components (i.e. initial orientation, fixation frequency and fixation time) were calculated for each stimulus pair (i.e. happy-neutral, angry-neutral, and sad-neutral), where scores greater than 0.5 indicate a preferential attention to the emotional faces rather than the neutral faces, whereas scores lower than 0.5 indicate preferential attention towards the neutral faces rather than the emotional faces. These measures have been reliably used in previous eye-tracking studies of selective attention to emotional faces (Leyman, De Raedt, Vaeyens, & Philippaerts, 2011).

Data analysis
A series of zero-order correlation analyses was conducted to test the relationships between SWB components, the relationships between behavioral indices of attentional processing to emotional faces and, finally, the relationships between SWB components and behavioral indices of attentional processing.

We then tested within-person differences across the types of faces through a series of mixed-design analyses of variance (ANOVA) with emotional face (happy, angry, and sad) as the within-subject factor, for each attention component (i.e. initial orientation, fixation frequency, and fixation time). Subsequently, we also conducted a series of mixed-design analyses of covariance (ANCOVA) for each attention component with SWB components (i.e. positive emotions, negative emotions, and LS) as covariates, in order to test the role of SWB components in differential attention patterns to each type of emotional face.

Finally, a series of bootstrapping analyses was conducted to test the interplay between emotional (i.e. positive or negative mood) and cognitive-evaluative (i.e. satisfaction with life) SWB components in predicting attentional behavior to emotional faces. These analyses were conducted for attention indices for which significant associations with SWB components were found.
Results

Relationships between SWB components

Table 1 shows the means and standard deviations of the variables measured in the study.

A series of correlation analyses was conducted to test the association between SWB variables. Analyses showed significant associations between both emotional and cognitive-evaluative SWB variables. Positive mood was positively associated with LS ($r = 0.508$, $p = 0.001$) and negatively associated with negative mood ($r = -0.455$, $p = 0.001$). Negative mood showed a trend towards a negative association with LS, but did not reach statistical significance ($r = -0.203$, $p = 0.066$).

Relationships between indices of attentional behavior to emotional faces

Table 2 shows the zero-order correlation coefficients for the association between attention indices. Each initial orientation index was significantly related with the fixation frequency index for the corresponding emotional category. Thus, a higher pattern of initial fixations in a given emotional category was associated with a higher frequency of fixations to that category. Initial orientation to happy faces was also significantly related with a higher fixation time to happy faces. Furthermore, all fixation frequency and fixation time indices were inter-correlated. Specifically, fixation frequency and fixation time to happy faces were negatively associated with fixation frequency and fixation time to both angry and sad faces, whereas fixation frequency and fixation time to angry and sad faces were positively associated between them.

Within-person differences across attentional behavior to emotional faces

We performed a series of analyses to contrast within-person differences in the processing of each type of emotional face and to test whether SWB components accounted for those differences. First, a series of mixed-design ANOVAs with type of emotional face (happy, angry, and sad) as the within-subject factor were conducted for each attention component (i.e. initial orientation, fixation frequency, and fixation time). Then, a series of ANCOVAs were performed with emotional face (happy, angry, and sad) as the within-subject factor and positive emotions, negative emotions, and LS as covariates, for each attention component.

For initial orientation, an ANOVA showed a significant main effect for emotional faces, $F(2, 164) = 15.52$, $p < 0.01$, $\eta^2 = 0.16$. Bonferroni-corrected posthoc comparisons showed that this effect was qualified by a significantly higher initial orientation to happy faces compared to initial orientation to angry and sad faces ($p < 0.01$, in both cases). However, when SWB components were included in the ANCOVA, this main effect did not reach significance, $F(2, 158) = 0.37$, ns, $\eta^2 = 0.01$, and none of the covariates reached significance either (all $F$'s $< 1.13$, all $p$'s $> 0.05$, all $\eta^2 < 0.02$).

For fixation frequency, an ANOVA also showed a significant main effect for emotion, $F(2, 164) = 42.03$, $p < 0.01$, $\eta^2 = 0.34$. Bonferroni-corrected posthoc comparisons showed that this effect was qualified by a significantly higher fixation frequency to happy faces compared to angry and sad faces ($p < 0.01$, in both cases). However, when SWB components were included in the ANCOVA this main effect did not reach...
significance, $F(2, 158) = 0.34$, ns, $\eta^2 = 0.01$, and the covariate positive emotions emerged as the significant factor accounting for this contrast effect (positive emotions × emotion: $F(2, 158) = 3.56$, $p < 0.05$, $\eta^2 = 0.05$). Neither negative emotions nor LS reached significance, $F(2, 158) = 0.68$, ns, $\eta^2 = 0.01$, and $F(2, 158) = 0.11$, ns, $\eta^2 = 0.01$, respectively.

Finally, for fixation time, an ANOVA showed a significant main effect for emotion, $F(2, 164) = 38.83$, $p < 0.01$, $\eta^2 = 0.32$, which was qualified by a significantly higher fixation time to happy faces compared to angry and sad faces, according to corrected Bonferroni comparisons ($p < 0.01$, in both cases). When SWB components were included in the ANCOVA, this main effect did not reach significance, $F(2, 158) = 0.71$, ns, $\eta^2 = 0.01$, and the covariate positive emotions emerged as the significant factor accounting for this contrast effect (positive emotions × emotion: $F(2, 158) = 3.95$, $p < 0.05$, $\eta^2 = 0.05$). Neither negative emotions nor LS reached significance, $F(2, 158) = 0.59$, ns, $\eta^2 = 0.01$, and $F(2, 158) = 0.33$, ns, $\eta^2 = 0.01$, respectively.

Overall, analyses indicated a series of contrast effects qualified by higher initial orientation, fixation frequency, and fixation time to happy vs. negative (angry and sad) faces across the sample. This higher attentional selectivity to happy faces was qualified by the positive emotion levels, specifically in regard to fixation frequency and fixation time.

**Bootstrapping analyses**

We conducted a series of bootstrapping analyses to test the interplay between emotional (i.e. positive and negative mood) and cognitive-evaluative (i.e. satisfaction with life) SWB components in predicting attentional behavior to emotional faces. Specifically, we examined path models of indirect effects to test, first, whether the cognitive-evaluative SWB component influenced attention behavior via their influence in emotional SWB components, and, second, whether a reversed model in that emotional SWB component influenced attention behavior via its influence in the cognitive-evaluative SWB component. These analyses were conducted for attentional indices for which associations with SWB variables were significant (i.e. fixation frequency to happy and sad faces, and fixation time to happy faces). To test these indirect effect
models, we used a bootstrapping method, with 5000 bootstrap resamples using a 95% confidence interval (Hayes, 2013). Thus, for each index, we first tested the indirect effect models in which emotional SWB components mediated the influence of LS on attentional behavior to emotional information. Then, concurrent with previous research (Tugade & Fredrickson, 2004), we also explored the validity of reversed alternative models in which LS mediated the influence of emotional SWB components on attentional indices.

Bootstrapping analyses were conducted following guidelines provided by Mallinckrodt, Abraham, Wei, and Russel (2006). First, bootstrapped estimates of paths $a$ (predictor → mediator), $b$ (mediator → criterion), and $c$ (predictor → criterion) paths were performed. Second, bootstrapped estimates of path $c'$ were performed to test the mediation model by which the predictor has no effect in the criterion when the mediator is controlled. Finally, the true indirect effect for the mediation models was tested through bootstrapped estimates of the product of paths $a$ and $b$ ($a \times b$). Statistical significance for each path tested was established when zero did not lie between the 95% confidence interval estimated (Hayes, 2013).

**Fixation frequency to happy faces**

The first set of indirect effect models used LS as the independent variable and positive and negative mood as potential mediators. Results from this set of bootstrapped estimates are reported in Table 4.

For the model testing negative mood as a mediator variable, only paths $b$ and $c$ reached significance. Thus, both LS and negative mood significantly predicted fixation frequency to happy faces, but negative mood did not account for the relationship between LS and fixation frequency to happy faces.

For the model testing positive mood as a mediator variable, paths $a$, $b$, and $c$ reached significance. Furthermore, when positive mood was controlled, LS had no effect in fixation frequency to happy faces (path $c'$). Finally, the true indirect effect for the model ($a \times b$) was estimated to lie between 0.001 and 0.002. Since zero is not in the 95% confidence interval, we can conclude that the indirect effects were significantly different from zero at $p < 0.05$, and that positive emotions accounted for the relationship between LS and fixation frequency to happy faces. The alternative set of reversed models with positive and negative mood states as independent variables and LS as the potential mediator variable did not produce any significant results. The true indirect effects for these models were estimated to lie between $-0.001$ and 0.001 and between $-0.001$ and 0.001, respectively.

In order to confirm that the effect of positive mood on the association between LS and fixation frequency to happy faces was not accounted by the influence of negative mood, we tested a final indirect effect model that included negative mood as a covariate. Once again, LS was the independent variable and positive mood was identified as the mediator variable. Analyses confirmed the indirect effect model. Once the influence of negative mood was controlled, positive mood continued to account for the relationship between LS and fixation frequency to happy faces. The true indirect effect for this model was estimated to lie between 0.001 and 0.002, different from zero at $p < 0.05$.

**Fixation frequency to sad faces**

For the first indirect effect model for which LS was the independent variable and negative mood state was the potential mediator, only path $b$ reached significance, $B = 0.001$, SD = 0.001, 95% CI = 0.001 to 0.002.

Table 4. Bootstrap analyses of the significance of mediation effects (criterion variable: fixation frequency to happy faces).

<table>
<thead>
<tr>
<th>Path/effect</th>
<th>$B$ mean indirect effect</th>
<th>SE of mean</th>
<th>95% CI mean indirect effect</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>Mediational model: LS → NegatMood → FixFreqHappy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a$ (LS → NegatMood)</td>
<td>−0.214</td>
<td>0.124</td>
<td>−0.444 to 0.039</td>
</tr>
<tr>
<td>$b$ (NegatMood → FixFreqHappy)</td>
<td>−0.001</td>
<td>0.001</td>
<td>−0.648 to −0.002*</td>
</tr>
<tr>
<td>$c$ (LS → FixFreqHappy)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001 to 0.002*</td>
</tr>
<tr>
<td>$c'$</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001 to 0.001</td>
</tr>
<tr>
<td>$a \times b$</td>
<td>0.002</td>
<td>0.002</td>
<td>−0.001 to 0.001</td>
</tr>
<tr>
<td>Mediational model: LS → PositMood → FixFreqHappy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a$ (LS → PositMood)</td>
<td>0.506</td>
<td>0.107</td>
<td>0.297 to 0.711*</td>
</tr>
<tr>
<td>$b$ (PositMood → FixFreqHappy)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001 to 0.002*</td>
</tr>
<tr>
<td>$c$ (LS → FixFreqHappy)</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001 to 0.002*</td>
</tr>
<tr>
<td>$c'$</td>
<td>0.000</td>
<td>0.001</td>
<td>0.001 to 0.001</td>
</tr>
<tr>
<td>$a \times b$</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001 to 0.002*</td>
</tr>
</tbody>
</table>

Note: LS = life satisfaction; NegatMood = negative mood; PositMood = positive mood; FixFreqHappy = fixation frequency to happy faces.

*Zero is not in the 95% confidence interval (indirect effect significantly different from zero at $p < 0.05$).
For the second indirect effect model for which LS was the independent variable and positive mood state was the potential mediator, both paths $a$ and $b$ reached significance, $B = -0.001$, SD = 0.001, 95% CI = -0.002 to -0.001, and $B = 0.001$, SD = 0.001, 95% CI = 0.001–0.002, respectively. However, path $c$ did not reach significance, $B = -0.001$, SD = 0.001, 95% CI = -0.002 to 0.001.

Thus, LS did not predict fixation frequency to sad faces and only negative and positive mood states were significant predictors. In order to test the specific role of each emotional SWB variable in predicting fixation frequency to sad faces, further bootstrap estimations for these factors were performed by entering both negative mood and positive mood together in the regression equation with fixation to sad faces as criterion variable. This analysis showed that whereas positive mood continued reaching significance, $B = -0.006$, SD = 0.003, 95% CI = -0.011 to -0.001, negative mood failed to reach significance when positive mood was controlled, $B = 0.002$, SD = 0.002, 95% CI = -0.002 to 0.007.

**Fixation time to happy faces**

For the first set of indirect effect models, LS was the independent variable and positive and negative mood states were the potential mediators. Results from this set of bootstrapped estimates are reported in Table 5.

For the model testing negative mood as a mediator variable, only paths $b$ and $c$ reached significance. Moreover, path $c'$ continued reaching significance and the true indirect effect for path $a \times b$ did not. Thus, we can conclude that negative mood was a significant predictor of fixation time to happy faces, but that it did not account for the association between LS and fixation time to happy faces.

For the model testing positive mood as a mediator variable, paths $a$, $b$, and $c$ reached significance. Furthermore, when positive mood was controlled LS had no effect in fixation frequency to happy faces (path $c'$).

Finally, the true indirect effect for the model ($a \times b$) was estimated to lie between 0.001 and 0.004, indicating that positive mood accounted for the relationship between LS and fixation time to happy faces. The alternative set of reversed models that used positive and negative mood states as independent variables and LS as the potential mediator variable did not produce any significant results. The true indirect effects for those reversed models were estimated to lie between -0.001 and 0.002 and between -0.001 and 0.001, respectively.

To confirm that the indirect effect of positive mood on the association between LS and fixation time to happy faces was not influenced by negative mood, we tested a final model in which negative mood was entered as a covariate. Analyses confirmed the model. Once the influence of negative mood was controlled, positive mood continued to account for the relationship between LS and fixation time to happy faces. The true indirect effect for the model was estimated to lie between 0.001 and 0.003, different from zero at $p < 0.05$.

**Table 5.** Bootstrap analyses of the significance of mediation effects (criterion variable: fixation time to happy faces).

<table>
<thead>
<tr>
<th>Path/effect</th>
<th>$B$ mean indirect effect</th>
<th>SE of mean</th>
<th>95% CI mean indirect effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mediation model: LS $\rightarrow$ NegatMood $\rightarrow$ FixTimeHappy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a$ (LS $\rightarrow$ NegatMood)</td>
<td>−0.214</td>
<td>0.124</td>
<td>−0.444</td>
</tr>
<tr>
<td>$b$ (NegatMood $\rightarrow$ FixTimeHappy)</td>
<td>−0.018</td>
<td>0.005</td>
<td>−0.029</td>
</tr>
<tr>
<td>$c$ (LS $\rightarrow$ FixTimeHappy)</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>$c'$</td>
<td>0.014</td>
<td>0.006</td>
<td>0.001</td>
</tr>
<tr>
<td>$a \times b$</td>
<td>0.001</td>
<td>0.001</td>
<td>−0.001</td>
</tr>
<tr>
<td>Mediation model: LS $\rightarrow$ PositMood $\rightarrow$ FixTimeHappy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$a$ (LS $\rightarrow$ PositMood)</td>
<td>0.506</td>
<td>0.107</td>
<td>0.297</td>
</tr>
<tr>
<td>$b$ (PositMood $\rightarrow$ FixTimeHappy)</td>
<td>0.025</td>
<td>0.007</td>
<td>0.012</td>
</tr>
<tr>
<td>$c$ (LS $\rightarrow$ FixTimeHappy)</td>
<td>0.003</td>
<td>0.001</td>
<td>0.001</td>
</tr>
<tr>
<td>$c'$</td>
<td>0.006</td>
<td>0.007</td>
<td>−0.009</td>
</tr>
<tr>
<td>$a \times b$</td>
<td>0.002</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Note: LS = life satisfaction; NegatMood = negative mood; PositMood = positive mood; FixTimeHappy = fixation time to happy faces.

*Zero is not in the 95% confidence interval (indirect effect significantly different from zero at $p < 0.05$).

**Discussion**

Our study provides support for the idea that SWB is related to the way in which individuals select emotional information from their environment. Our hypothesis that both the emotional and cognitive components of SWB would be associated with a higher likelihood of attentional processing of positive facial expressions was generally supported. Attention towards happy faces was positively correlated with positive mood and LS, and
negatively correlated with negative mood. These findings are congruent with previous research that has reported positive relationships between naturally positive mood states and LS with attention to positive information by using RT measures of selective attention, such as the dot-probe task (Tamir & Robinson, 2007; Vittesø et al., 2009). Conversely, attention towards sad faces was negatively associated with positive mood and LS, and positively associated with negative mood. These findings were significant for measures related to elaborative processing (i.e. number of fixations and total time spent looking at emotional faces). However, positive mood was not associated to initial orientation bias (i.e. first fixation), suggesting that a vigilance bias for positive information is not characteristic of a positive emotional state, which is in turn linked with elaborative processing of that information.

This pattern of associations also emerged when analyzing with-in person differences in attention to each type of emotion category. In all the attention components evaluated, a similar pattern of contrast effects emerged, as participants were characterized by a significantly higher initial orientation, fixation frequency, and fixation time to happy faces in comparison to negative faces (both angry and sad faces). When the role of SWB components was considered in these contrast effects, positive mood emerged as the factor implicated in this higher attentional selectivity to happy faces, specifically for the elaborative processing components (i.e. fixation frequency and fixation time) but not for initial orientation.

Evidence for the role of mood in selective attention has traditionally come from studies that involve participants experiencing altered moods due to a psychiatric condition. Although information on healthy control participants, who are not clinically depressed or anxious, is generally provided in these studies, details of their mood are rarely assessed or reported. Nevertheless, indirect evidence from these studies may be helpful in understanding our findings, as results from these studies have demonstrated a link between altered moods and selective attention processes (Mathews & MacLeod, 2005). A meta-analysis by Armstrong and Olatunji (2012) of depressed and anxious individuals (33 experiments; N=1579) showed that, relative to healthy control participants, anxious individuals showed increased vigilance for threat, as measured through eye tracking. In contrast, depressed participants did not show vigilance for threat during free observation; however, they demonstrated reduced orientation and gaze maintenance to positive stimuli as well as increased maintenance of gaze on dysphoric stimuli. The lack of association between SWB components and initial orientation to emotional information is similar to findings from eye-tracking studies of depressed individuals in processing negative stimuli; however, it contrasts with vigilance biases of threat-related information observed in those with anxiety (Armstrong & Olatunji, 2012). Therefore, in this respect, the pattern of gazes towards positive stimuli in relation to positive mood and LS reflects the one found between depression and negative stimuli.

The second major finding, based on bootstrapping analyses, was that the relationship between LS and attention to happy faces (indicated by more fixations and time spent looking at them) was fully explained by positive mood even after controlling for any potential effects of negative mood. The pattern of associations between SWB components and attention to positive information indices is summarized in Figure 2. Our findings indicate that, despite the cognitive nature of making assessments of LS (Diener, 1984), this type of overall appraisal appears to be affected more by bottom-up cognitive processes (e.g. heuristics) than emotional states. This is consistent with the idea that LS is a stable characteristic and therefore less vulnerable to contextual circumstances (Schimmack & Oishi, 2005). Specifically, our analyses support the idea that LS may predispose individuals to certain mood states (e.g. Gamble & Gärling, 2012; Rusting & DeHart, 2000) which can then influence emotional processing, for example, by increasing attentional processing of positive information as consistently explained by an emotional-congruency framework (Bower, 1981).

Our results raise important questions about the contribution of attentional processing patterns to positive mood and LS. According to Fredrickson’s influential theory, positive emotions broaden an individual’s perception and attention, and are thought to contribute to the development of personal resilience (Tugade & Fredrickson, 2004; Fredrickson & Branigan, 2005; Biss & Hasher, 2011; Rowe et al., 2007). Bruyneel and colleagues (2013) did not find evidence of this; however, our results showed that positive emotions were relevant in selecting...
positive information and maintaining its processing. Unfortunately, despite the robustness of our results, our methodological design did not enable us to analyze the causality of this connection. Although it is possible that changes in mood alter psychological functioning, as shown convincingly in the literature on mood induction and cognition (Ashby et al., 1999; Matt et al., 1992), it is also possible that selective attention biases may change mood. Evidence for the latter is derived from recent studies showing that training attention biases towards positive stimuli or away from negative stimuli may enhance mood in participants with anxiety or depression (Hallion & Ruscio, 2011; Browning, Holmes, & Harmer, 2010; Mobini, Reynolds, & Mackintosh, 2013). Other studies that have employed similar attention training with healthy participants have also demonstrated that focusing on positive stimuli minimizes negative moods. For instance, participants trained to focus on positive words (Wadlinger & Isaacowitz, 2008; Grafton et al., 2012) or happy faces (Johnson, 2009) had altered gaze patterns and reactivity in a later emotional test. There is also evidence from the field of depression that a bias for happy faces, as measured via eye-tracking technology, contributed to healthy participants’ ability to recover faster following an induced sad mood (Sanchez, Vazquez, Gomez, & Joormann, 2013). These new sources of direct and indirect evidence (see MacLeod & Mathews, 2012) provide support for the hypothesis that the relationship between attentional biases and positive mood might be bidirectional. Further studies are needed to explore the fascinating possibility that attentiveness towards positive stimuli is not only a consequence of an individual’s current mood, as has been traditionally considered in mood congruency models, but may also play a role in mood regulation (Wadlinger & Isaacowitz, 2011; Sanchez, Vazquez, Marker, LeMoult, & Joormann, 2013).

There are some limitations to our study. Although our experimental paradigm used emotional faces and a free observational procedure, stimuli were rather abstract and decontextualized. In real life interactions, faces appear within a given social context and typically exist concomitantly with other stimuli (e.g. verbal, auditory, or body posture information). Therefore, future research might combine information from different modalities to better emulate the analysis of information processing in real-life situations (Wieser & Brosch, 2012). Faces are also typically dynamic in nature and recent research has shown that dynamic faces, compared to static ones, are associated with an increase in responses among observers (Reichert et al., 2012). Another limitation is related to the type of emotion being studied. As in much of the research in the field, the scope of emotions studied is somewhat broad and vague. Although our results have consistently shown that gaze patterns are correlated with a global positive mood state (i.e. a composite score of happy, optimistic, joyful, and content), it would be convenient to focus on specific positive emotions. Recent research has shown that some effects, such as broadening of attention, are likely to be linked with a positive affect characterized by low-approach motivations (e.g. relaxed or content) rather than high-approach motivations (e.g. enthusiasm or desire) (Gable & Harmon-Jones, 2008). Therefore, it is possible that different positive emotions may differentially impact cognitive processes and, in particular, attentional processes. For instance, Griskevicius, Shiota, and Neufeld (2010) have used positive mood induction techniques to demonstrate that, although emotions such as amusement and love attachment tend to facilitate greater acceptance of persuasive messages, emotions of awe and nurturing love reduce persuasion by these messages. Thus, it would be interesting to investigate if specific positive moods are associated with different cognitive processes and selective attention.

Our results only provide information regarding associations between attention indices and SWB components. Future research should explore the extent to which selective attention is related to other cognitive processes (e.g. memory or attributions) that may also be associated with SWB. For example, Philippe, Koestner, Beaulieu-Pelletier, Lecours, and Lekes (2012) have shown that episodic memories are associated with LS as long as they are related to the satisfaction of basic needs, suggesting that even the most abstract component of SWB, satisfaction with life, can be linked to basic cognitive operations that are psychologically meaningful (Greenhoot & McLean, 2013). To summarize, our methodology, which was generally more robust than those of previous studies, found that some components of selective attention were associated with LS and even more importantly, with positive moods. Further research should address the contextual limits of these findings in addition to the functionality of these biases in processes of mood regulation.

Acknowledgments
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Notes
1. Analyses showed that the three groups of selected emotional pictures did not differ in discreteness from the corresponding emotion, $F(2, 81) = 1.21$, ns, $\eta^2 = 0.029$, or in intensity, $F(2, 81) = 1.39$, ns, $\eta^2 = 0.03$. The mean scores for emotional discreteness for the happy, angry and sad expressions were 5.53 (SD = 0.39), 5.39 (SD = 0.52) and 5.32 (SD = 0.62), respectively. Mean intensity scores were 5.55 (SD = 0.51), 5.86 (SD = 0.58), and 5.76 (SD = 0.94), respectively.
2. Further bootstrapping analyses on the relationships between SWB components in predicting attention to emotional faces were performed controlling for the covariability of attention to the other types of emotional faces. Specifically, for each set of bootstrapping analyses (e.g., SWB components predicting fixation frequency to happy faces), attentional indices to the other two types of emotional faces (e.g., angry and sad faces) were entered in the models as covariates. Results were identical to those referred in the text in all cases, supporting the models in that positive emotions accounted for the influence of LS in fixation frequency and fixation time to happy faces, and not supporting the reversed models of SWB relationships in predicting attention behavior to emotional faces.

References


Schimmack, U., Schimmack, W., & Wagner, G. G. (2008). The influence of environment and personality on the affective and


