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Facial expression movement enhances the measurement of temporal dynamics of attentional bias in the dot-probe task

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ABSTRACT

The facial dot-probe task is one of the most common experimental paradigms used to assess attentional bias toward emotional information. In recent years, however, the psychometric properties of this paradigm have been questioned. In the present study, attentional bias to emotional face stimuli was measured with dynamic and static images of realistic human faces in 97 college students (63 women) who underwent either a positive or a negative mood-induction prior to the experiment. We controlled the bottom-up salience of the stimuli in order to dissociate the top-down orienting of attention from the effects of the bottom-up physical properties of the stimuli. A Bayesian analysis of our results indicates that 1) the traditional global attentional bias index shows a low reliability, 2) reliability increases dramatically when biased attention is analyzed by extracting a series of bias estimations from trial-to-trial (Zvielli, Bernstein, & Koster, 2015), 3) dynamic expression of emotions strengthens biased attention to emotional information, and 4) mood-congruency facilitates the measurement of biased attention to emotional stimuli. These results highlight the importance of using ecologically valid stimuli in attentional bias research, together with the importance of estimating biased attention at the trial level.

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1. Introduction

Biased attentional processing is often measured with the dot-probe task using emotional stimuli (MacLeod, Mathews, & Tata, 1986). The facial dot-probe task, in particular, is considered one of the most important paradigms in attentional bias research. It requires the simultaneous presentation of two faces (*e.g.*, one sad, one neutral) for a brief duration. After offset, a probe appears with equal probability at the location of one of the two faces. An attentional bias toward emotional information is revealed by relatively faster responses to probes replacing expressive faces than to probes replacing neutral faces. But is the emotional dot-probe task adequate for measuring biased selective attentional processing?

1.1. *Attentional biases to emotional information*

An attentional bias derived from the dot-probe task has been reported in clinical samples and in non-clinically anxious individuals, but much less frequently in depression (Mogg & Bradley, 2005) and in typical non-clinical individuals (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). Some studies have reported an attentional bias away from emotional faces (Heuer, Rinck, & Becker, 2007; Mansell, Clark, Ehlers, & Chen, 1999) whereas other studies have reported an attentional bias toward emotional faces (see Yiend, Barnicot, & Koster, 2013). Such discordant results have been explained by methodological differences in the studies (Bögels & Mansell, 2004), by the stimuli that had been used (Dear, Sharpe, Nicholas, & Refshauge, 2011), by the timing parameters and the number of trials (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Ijzendoorn, 2007), and by the moderating effects of individual differences (Clarke, MacLeod, & Shirazee, 2008).

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However, recent studies have pointed out that the dot-probe task is inherently problematic because of the very low reliability of the response-time (RT) measures derived from the dot-probe data (*e.g.*, Price et al., 2015). Such low reliability may also explain the lack of association between biased attentional processing and psychological malfunctioning that has been reported in several studies (*e.g.*, Kappenman, Farrens, Luck, & Proudfit, 2014). The problem of reliability is even more important if, on the one side, we consider reliability as prerequisite for validity (*i.e.*, the ability of a measure to covary with other outcomes), and, on the other, we recognize that the dot-probe paradigm has been recently applied in clinical settings (*e.g.*, Waters, Wharton, Zimmer-Gembeck, & Craske, 2008).

1.2. Psychometric properties of response time difference scores

Reliability is defined as the proportion of variance in a set of observed scores that reflects the variance of true scores (as opposed to measurement error). Reliability can be estimated in a number of ways. Internal consistency reliability is often measured using Cronbach's α. One related measure is split-half reliability, in which the participants' scores on one-half of their measures are correlated with the scores on the second half of the observed scores, after correcting for test length.

With questionnaires and psychological tests, reliability values above 0.80 are considered good and values below 0.60 are considered very low (*e.g.*, Murphy & Davidshofer, 2005). It is not clear, however, whether such cut-off points can be directly applied to a behavioral measure based on response times, given that the attentional bias index is computed from a much smaller number of "items" (*i.e.*, scores obtained in each experimental condition) and from a much smaller sample size than in typical psychometric testing.[1]

Waechter and Stolz (2015) have noted that the bias score (BS), being based on RT difference scores [*i.e.*, the difference between the mean RTs of all trials in which the probe replaces the neutral face (incongruent trials) and the mean RTs of all trials in which the probe replaces the expressive face (congruent trials)], will necessarily have a lower reliability than any measure based on the raw RTs. This statistical phenomenon arises from the fact that, when the difference between two measurements of the same construct is computed, their true values tend to cancel each other out. In the extreme case in which the RTs have identical true-score components in two conditions, their difference only reflects the error components of the two measures, with zero reliability (see also Miller & Ulrich, 2013). In principle, therefore, the reliability of the BS will tend to be lower than what is found in traditional psychometric testing. Rather than making a comparison with an absolute standard, it thus seems more useful to investigate the stimulus conditions that produce a stronger and more reliable BS, especially when comparing individuals with different degrees of psychological distress.

1.3. The reliability of the global attentional bias index

In the dot-probe task, biased attention to emotional information has been traditionally conceptualized as a static trait that is stable over time, under the assumption that each participant has the tendency to manifest an attentional bias either toward or away from the relevant stimuli (see Zvielli, Bernstein, & Koster, 2015a; 2015b). A small number of studies have examined the reliability of the BS defined as indicated in the previous section (which we will call "global bias index"). For example, Schmukle (2005) and Staugaard (2009) evaluated the reliability of the global bias index in unselected undergraduate participants by using words or emotional faces as stimuli. In both cases, reliability was very low, with Cronbach's α taking on negative values and not exceeding 0.31 (Staugaard, 2009) and 0.28 (Schmukle, 2005). Test-retest reliability did not exceed 0.32 (Schmukle, 2005). Cooper et al. (2011) found reliability estimates between −0.33 and 0.48. Bar-Haim et al. (2010) examined the effects of vigilance toward threat and anxiety in civilians within and outside rocket range in the Israel-Gaza war and, for the word version of the dot-probe task, found a split-half reliability of 0.45. With the facial dot-probe task, Waechter, Nelson, Wright, Hyatt, and Oakman (2014) found Cronbach's α reliabilities between −0.18 and 0.30. Price et al. (2015) conducted a systematic investigation of the effects of different outlier-handling methods. In their study, the intraclass correlation coefficient (ICC) did not exceed 0.19 for a single administration of the dot-probe task, but reached the level of 0.65 for the combined administrations of the dot-probe task across eight time points. In summary, the available data suggest that the reliability of a single administration of the dot-probe task remains well below the levels typically recommended for psychometric adequacy.

1.4. The reliability of the trial-level attentional bias scores

Recently, Zvielli, Bernstein, and Koster (2015b) have pointed out that, far from being stable over time, biased attention is a dynamic process which manifests fluctuating phasic bursts over time, toward or away from the relevant stimuli. As a consequence, they proposed a novel trial-level computation of the bias score (TL-BS), which takes into consideration its dynamic nature over time. The BS is still measured as the RT difference between incongruent and congruent trials, but this difference is computed by considering pairs of temporally contiguous (incongruent and congruent) trials. The TL-BS scores thus create a sequence of trial-level difference scores that reflect the trial-by-trial variations of attention.

A number of recent studies suggest that the TL-BS scores have better psychometric properties than the global bias index. For example, Amir, Zvielli, and Bernstein (2016) reported split-half reliabilities in the range from −0.23 to 0.39 for the global bias index and in the 0.40−0.81 range for the TL-BS scores; Zvielli, Vrijssen, Koster, and Bernstein (2016) reported split-half reliabilities in the 0.10−0.23 range for the global bias index and in the 0.59−0.90 range for the TL-BS scores (see also Davis et al., 2016; Rodebaugh et al., 2016; Schäfer et al., 2016).

1.5. Detrimental effect of uncontrolled bottom-up salience on attentional bias scores

The low reliability of the dot-probe task may not depend solely on the use of RT differences, but also on the physical properties of the visual stimuli. Although attention can be directed toward goal-related items, it is also involuntarily captured by stimuli that are particularly physically salient. The reliability of the dot-probe task may thus be negatively affected by the presence of different levels of bottom-up salience for neutral and expressive faces. Therefore, inconsistencies among results from different studies may depend, in part, on the lack of control for this stimulus-driven component of attention.

[1] Classical test theory shows that internal consistency reliability depends upon the number of test items (with shorter tests yielding lower reliability coefficients than longer tests), the dimensionality of the factor model which describes the construct, and the number of participants (with a larger sample size yielding higher reliability coefficients than a smaller sample size).

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