Emotion

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Measuring Distinct Emotional States Implicitly: The Role of Response Speed

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Affective science offers many self-report measures, but implicit measures of multiple distinct emotional states are lacking. Prior research (Bartoszek & Cervone, 2017) initiated the development of such an assessment method by examining whether ratings of the emotional content of abstract images reveal raters' emotional states. The current studies were designed to determine whether the speed of these ratings is key to the validity of an implicit emotion measure. To this end, Study 1 exploited naturally occurring variations in response times, whereas Study 2 used time pressure in responding to the implicit measure. Both studies featured a fear-induction and revealed that implicitly assessed fear correlated with psychophysiological (Study 1) and behavioral (Studies 1 and 2) responses even when controlling for self-reported fear. Importantly, results supported the construct, criterion, and incremental validity of the implicit measure only among participants who responded quickly. Study 3 employed a sadness-induction and an experimental manipulation of response times using fast- and slow-paced conditions. The emotion induction affected fast, but not slow, responses to the implicit measure. Overall, findings highlight the importance of response speed in implicit emotion assessment and suggest that the Implicit Measure of Distinct Emotional States can validly differentiate among emotions.

Keywords: implicit measure, affect, emotion, time pressure, psychophysiology

> We must never take a person's testimony, however sincere, that he has felt nothing as proof positive that no feeling has been there.
>
> —William James, 1890

A major challenge in the study of distinct emotional states is assessing them. Limitations of self-report, the most common assessment method, are well known (Mauss & Robinson, 2009; Quigley, Lindquist, & Feldman Barrett, 2014). First, some individuals evidence limited insight into their own emotional experiences (e.g., Smith & Lane, 2016; Weinberger, Kelner, & McClelland, 1997). This is particularly the case among those with symptoms of psychopathology (Kring, Siegel, & Barrett, 2014) and such conditions as alexithymia (e.g., Murphy, Catmur, & Bird, 2018) or affective agnosia (Lane, Weihs, Herring, Hishaw, & Smith, 2015). Second, individuals are not always forthcoming in their reports and show biases in their responses by under- or overreporting certain affective experiences (e.g., Barrett, 1996; Robinson & Clore, 2002). Third, the process of reporting one's emotional states changes the intensity of these states (Keltner, Locke, & Aurain, 1993) and decreases emotion-based psychophysiological activity (Kassam & Mendes, 2013). Therefore, even when individuals are perceptive about their emotions and unguarded in their reports, the use of self-report methods can be detrimental to the scientific study of affective states. Moreover, the fact that emotions might influence behavior but occur without conscious awareness further undermines the role of self-reports in the assessment of emotions (e.g., Winkielman & Berridge, 2004). The field thus needs alternatives to explicit self-report methods.

One alternative is to assess psychophysiological correlates of emotional states (e.g., Levenson, Ekman, & Friesen, 1990). Psychophysiological activity, however, varies more strongly as a function of nonemotional artifacts (e.g., physical and mental demands of emotion-induction procedures) than emotions per se (Sinha, 1996; Stemmler, Heldmann, Pauls, & Scherer, 2001). Physiological processes appear to be informative about emotional valence or arousal, but do not consistently differentiate distinct emotions (Larsen, Berntson, Poehlmann, Ito, & Cacioppo, 2008; Mauss & Robinson, 2009; Quigley et al., 2014).

Another strategy, coding facial expressions (e.g., Tian, Kanade, & Cohn, 2001), is also limited. Emotions might be revealed facially only in specific contexts (e.g., Parkinson, 2005; Russell,

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Parts of these findings were previously presented in a symposium titled "Ratings of ambiguous images uniquely reflect and differentiate emotional states" at the annual meeting of the Association for Psychological Science in May 2016.

All images and instructions of the Implicit Measure of Distinct Emotional States can be obtained from Gregory Bartoszek at https://www.bartoszek-laboratory.com/research-materials.html.

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1994), for subsets of participants, and when the emotional states are particularly intense (Bonanno & Keltner, 2004; Rosenberg & Ekman, 1994). Facial and related behavioral coding thus are not fully adequate for differentiating among distinct emotions of similar valence (Mauss & Robinson, 2009; Porter & ten Brinke, 2008; Quigley et al., 2014).

Cognitively Based Implicit Measures of Affect and Distinct Emotions

Another alternative for measuring distinct emotions implicitly involves cognitive responses. Because affective states systematically influence cognition, assessment of cognitive processes or contents can indirectly signal the presence of affective states. According to the affect infusion model (AIM), affect is especially likely to influence judgment when evaluated stimuli are unfamiliar and objective criteria for judgment are not available (Forgas, 1995, 2001).

In one proposed method, participants guess supposedly displayed "words" by selecting among options, some neutral (e.g., *GOWN*, *DAWN*, and *TOWN*) and one affective (e.g., *DOWN*; Hass, Katz, Rizzo, Bailey, & Moore, 1992; cf. Krieglmeyer, Wittstadt, & Strack, 2009). Another method, the Implicit Positive and Negative Affect Test (IPANAT; Quirin, Kazén, & Kuhl, 2009), requires participants to evaluate the positivity-negativity of artificial words (e.g., *TUNBA*). Mood influences these cognitive responses, with judgments corresponding to affective states and traits.

Yet, a limitation remains. Cognitively based implicit measures have primarily distinguished between affective states of different valence. One also needs assessments that can differentiate among distinct emotional states of the same valence. Prior work by the present authors has begun to tackle this task (Bartoszek & Cervone, 2017; also see Bode, 2014; Lee, Lindquist, Arbuckle, Mowrer, & Payne, 2020; Quirin & Bode, 2014). The current studies substantially extend this prior research by seeking to illuminate the psychological processes at work in implicit emotion assessment while, simultaneously, enhancing the validity of an implicit measure of distinct emotional states of potential widespread use in affective science.

Attributing Emotion to Abstract Images

In a paradigm introduced by Bartoszek and Cervone (2017), participants evaluate abstract images. Specifically, respondents judge, in a forced-choice format, the emotion that the artist tried to convey. Findings suggest that these responses can reveal the presence of distinct emotional states. Participants who had experienced a given emotion induction (sadness, anger, or fear) more frequently judged that the artist was trying to convey that emotion. Subsequent findings support the utility of this implicit assessment method (Bryant, Winer, Salem, & Nadorff, 2017; Holt, Furbert, & Sweetingham, 2019; Mantantzis, Maylor, & Schlaghecken, 2018; Wisneski & Skitka, 2017; also see Mackie & Smith, 2017; Wróbel, 2018).

Despite its unique promise, this task, as previously developed (Bartoszek & Cervone, 2017), is insufficient to measure emotional states among all persons. Findings revealed that the task's validity was compromised among participants who responded relatively slowly to test items. Therefore, the role of response speed in increasing the validity of implicit emotion measures appears to be paramount and was the focus of our current investigations.

Mechanisms Underlying Implicit Measures of Affect and Distinct Emotions: The Role of Response Speed

Theory and research in emotion science support the possibility that response speed is integral to the validity of implicit emotion measures. The psychological processes linking emotion and cognition differ qualitatively depending on whether people engage in slow, deliberate processing as opposed to quick, heuristic processing (Evans & Stanovich, 2013; Palkovics & Takáč, 2016). We propose that relatively fast processing will enhance the validity of the implicit emotion-assessment task developed previously (Bartoszek & Cervone, 2017).

A key psychological process through which feelings influence thoughts when people think quickly is feelings-as-information (Schwarz, 2011). In feelings-as information, people use their current emotions as a source of information when evaluating ambiguous stimuli. This occurs, in particular, when stimuli are evaluated rapidly. Slow deliberation might eliminate the link from affect to evaluative judgment (Schwarz, 2011; Schwarz & Clore, 1983; Scott & Cervone, 2002). A similar prediction results from the dual-process theory that distinguishes between Type I processes, which are intuitive, automatic, emotion-based, and thus fast, and Type II processes, which are analytic, deliberative, requiring working memory, and thus slow (Evans & Stanovich, 2013; Palkovics & Takáč, 2016).

Notably, findings obtained by Bartoszek and Cervone (2017) are consistent with the feelings-as-information and dual-process accounts. There, in Experiments 1 and 2 that measured response times, the effects of emotion manipulations on ratings of ambiguous images were much stronger among fast- than among slow-responding participants. Indeed, the participants who responded slowly displayed virtually no effect of the emotion inductions. In other words, when rating the painting images, the fast-responding participants seemed to follow their gut feelings relying on the fast Type I processes. In contrast, the slow-responding individuals likely used the Type II processes by methodically examining the contents of the abstract images.

These theoretical considerations and empirical results have an important implication for the design of implicit measures of emotional states. They suggest that implicit emotion measures that rely on cognitive responses will gain in validity if participants respond quickly.

This suggestion can be tested in two ways, both of which are pursued in the studies reported here. One empirical strategy is correlational in nature in that it explores naturally occurring variations in participants' response speed. A second strategy is experimental. By manipulating response times (e.g., imposing time pressure), one can create experimental conditions that vary in the degree to which participants are compelled to evaluate stimuli through quick, heuristic processes. Guided by the AIM (Forgas, 1995) and dual-process frameworks (Evans & Stanovich, 2013), we predict that fast responding either due to individual differences in response speed or due to imposed time pressure will increase the validity of our implicit measure of distinct emotional states.

This prediction is consistent with prior studies showing that time pressure increases reliance on emotions in judgments (e.g., Finucane, Alhakami, Slovic, & Johnson, 2000). For example, participants responding under time pressure (as opposed to no time pressure) more readily use their affect in interpretations of ambiguous situations (Kosnes, Pothos, & Tapper, 2010), judgments of life satisfaction (Siemer & Reisenzein, 1998), evaluations of an outgroup member (Dijker & Koomen, 1996), or risky decision making (Hu, Wang, Pang, Xu, & Guo, 2014). Risky decision making, when made under time pressure, is also more strongly related to participants' skin conductance levels, an index of emotional arousal (Persson, Asutay, Hagman, Västfjäll, & Tinghög, 2018). Time pressure also increases framing effects, which are theorized to be based on the emotional Type I processes (Guo, Trueblood, & Diederich, 2017).

Taken together, fast responding (e.g., due to time pressure) should enhance the sensitivity of the implicit measure of emotional states as indicated by increased effects of emotion manipulations on ratings of abstract images. It should also result in higher correlations between implicitly assessed emotions and other indices of emotional responding.

Emotional Response System (Non-)Coherence

Correlations between implicitly assessed emotions with various other components of emotional responding would provide strong support for the validity of the implicit measure. However, the components of emotional responding themselves (e.g., behavioral, physiological, experiential) seem only loosely linked if at all. Studies examining the coherence of the emotional response systems found moderate (e.g., Matsumoto, Nezlek, & Koopmann, 2007; Mauss, Levenson, McCarter, Wilhelm, & Gross, 2005; Rosenberg & Ekman, 1994), minimal or null (e.g., Mauss, Wilhelm, & Gross, 2004; Reisenzein, Bördgen, Holtbernd, & Matz, 2006), and even negative (e.g., Lacey, 1967; Lang, 1988; also see Barrett, 2006) associations.

Such mixed results indicate the presence of moderator variables. Indeed, the coherence of emotional response systems varies as a function of emotion regulation (Brown et al., 2019; Dan-Glauser & Gross, 2013), emotion intensity (Bonanno & Keltner, 2004; Mauss et al., 2005; Rosenberg & Ekman, 1994), awareness of bodily sensations (e.g., Sze, Gyurak, Yuan, & Levenson, 2010), age (e.g., Lohani, Payne, & Isaacowitz, 2018), and even the type of emotion itself (e.g., Anderson, Monroy, & Keltner, 2018; Mauss et al., 2005). Unsurprisingly, finding coherence of emotional responses has been challenging.

Evers and colleagues (2014) argued that the dual-process framework could elucidate these mixed findings. Consistent with their hypotheses, they found response coherence within indices of automatic Type I processes (i.e., implicit and physiological measures) and within reflective Type II processes (i.e., explicit self-reports and reflective behavior) but not between the two types of processes. Other studies similarly found that implicit measures of affect predicted autonomic nervous system correlates (e.g., cortisol levels) whereas self-reported mood did not (e.g., Abercrombie, Kalin, & Davidson, 2005; Quirin, Kazén, Rohrmann, & Kuhl, 2009).

Consequently, ratings of abstract images should uniquely predict other indices of emotional responses that rely on Type I processes (e.g., psychophysiological activity, spontaneous behavior) primarily among those who provide the ratings quickly. However, such quick responses to implicit measure items might not correlate highly (if at all) with measures indexing deliberate, Type II processes (e.g., self-reports).

Overview of the Current Research

The aim of this research is to test whether imposing time pressure on the implicit emotion-assessment task (Bartoszek & Cervone, 2017) or similar implicit measures increases the validity of such measures. To this end, three studies explore the role of response speed in measuring distinct emotional states implicitly. Study 1 exploits naturally occurring variations in response times to test the validity of the implicit measure separately among slow- and fast-responding participants. Study 2 investigates whether imposing time pressure in responding would increase the robustness of the measure. Both studies featured a fear induction and tested the criterion validity of the measure: specifically, the extent to which implicitly assessed fear correlated with psychophysiological activity (Study 1) and avoidance behavior (Studies 1 and 2). In Study 3, following the induction of sadness or relaxation, participants were compelled to respond either quickly or slowly to the items of the implicit measure.

Study 1

The first study addressed the previously unexplored role of response speed in implicitly measured fear. Following our previous procedure (Bartoszek & Cervone, 2017), we induced fear by showing spider-fearful individuals and control individuals spider images. However, in this study, we recorded the participants' response speed while they evaluated the ambiguous images of the implicit emotion-assessment task. We also tested whether these cognitive evaluations would predict noncognitive classes of emotional responses: psychophysiological reactivity and avoidance behaviors, especially beyond the predictive power of self-reported emotions.

We hypothesized that the speed of ratings of the ambiguous images would be key to the validity of the implicit emotion-assessment task: Implicitly assessed fear would predict physiological reactions and behavioral tendencies only among participants who respond relatively quickly to the items of the implicit assessment.

Method

Participants and procedure. Undergraduates enrolled in introductory psychology completed the Fear of Spiders Questionnaire (FSQ; Szymanski & O'Donohue, 1995), among other surveys, at the outset of the semester. Two groups (N = 84; 55 women and 29 men; $M_{\text{age}} = 19.4$, $SD = 1.16$) were preselected: 44 spider-fearful individuals (FSQ ≥ 72; $M = 101.70$, $SD = 13.37$) and 40 control individuals (FSQ ≤ 18; $M = 5.45$, $SD = 5.31$; cf. Bartoszek & Winer, 2015).[1] One spider-fearful participant withdrew from the study after completing the psychophysiological assessment leaving no self-report or behavioral data. Participants were 31% (26) White, 8% (7) Black, 20% (17) Asian, 35% (29) Latino, and 5% (4) other.

[1] In all three studies, a power analysis determined the minimum sample size needed to achieve the recommended statistical power of 80% in an ANOVA test with the expected medium effect size ($f = .25$, based on our prior findings) and alpha error set to 0.05.

Upon arriving in the laboratory and following the informed consent procedure and sensor placements, participants started the experimental tasks (programmed using MediaLab software; Jarvis, 2004). Initially, participants were asked to sit quietly and to look at a blank screen for about 2 min to reduce any initial emotions. Figure 1 presents the flowchart of the experimental procedures that followed. First, participants completed the implicit emotion-assessment task, in which they rated abstract painting images. To induce fear, a spider image, displayed for one second, preceded each abstract image. Participants were asked to ignore the real-life (i.e., spider) images and to rate only the painting images. Second, participants were asked to sit as still as possible and to look at the images presented on the screen while their psychophysiological reactivity was recorded. They viewed, for approximately 9 min, 20 spider and 20 neutral images presented randomly one at a time. Each image was displayed for 5 s with an 8-s blank screen interval between the images. Third, after removing the physiological sensors, the participants completed the behavioral measure task (described subsequently) during which spider and positive pictures were presented without any time limit. Fourth, the participants completed self-report affective measures, provided demographic information, and were debriefed.

Materials and measures.

The implicit emotion-assessment task. The implicit emotion assessment task was administered and scored in the same manner as in Bartoszek and Cervone (2017). Participants viewed 20 abstract images presented individually in random order. They answered the question, "What emotion did the artist try to express in this painting?" by selecting one of five response options: *anger*, *fear*, *happiness*, *sadness*, or *none*, without any time restrictions.

The four implicit emotion scores were computed by summing the number of pictures rated to display a particular emotion. Of note is that by chance alone, each of the five response options would be attributed, on average, to four abstract images (20 images/five responses); thus, a score of four on the implicit emotion-assessment task represents the chance level of responding.

Self-report measures. Emotions were also assessed explicitly with selected subscales of the Positive and Negative Affect Schedule–Expanded form (PANAS-X; Watson & Clark, 1994), which has good convergent and discriminant validity. Participants reported, on a five-point Likert scale (1 = *not at all* to 5 = *extremely*), the extent to which each of 25 adjectives described

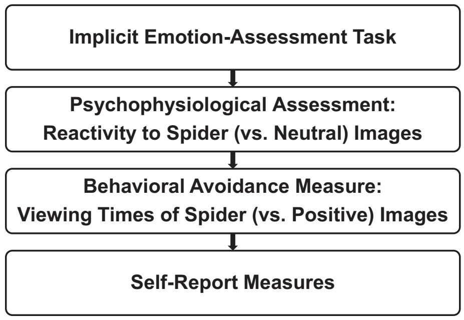

Figure 1. Flowchart illustrating chronological order of tasks in Study 1.

emotions they experienced when viewing the spider images. Each adjective referred to one of four PANAS-X subscales: Hostility (*anger*), Fear, Sadness, or Joviality (*happiness*). The order of the adjectives was randomized. Additionally, participants rated, on a five-point scale (1 = *not at all* to 5 = *extremely*), how frightening they had found the spider pictures (fright ratings of spider pictures).

Participants also completed the Beck Anxiety Inventory (BAI; Beck & Steer, 1990), which measures anxiety-related physiological symptoms of arousal (e.g., heart pounding, shaky, sweating) and which has good psychometric properties. In this study, the standard BAI instructions to report symptoms experienced "in the last week, including today" were replaced with "while looking at the spider pictures" (hereafter, BAI-Sp).

Last, participants expressed degrees of agreement (0 = *totally disagree* to 7 = *totally agree*) with each of 18 statements that compose the FSQ. The FSQ has good internal consistency (α = .92) and good convergent validity and differentiates well between individuals with spider phobia and those without (Szymanski & O'Donohue, 1995).

Behavioral avoidance measure. A measure of behavioral avoidance involved a task in which participants chose how long they would observe randomly presented on-screen pictures, 20 of which were positive (from Lang, Bradley, & Cuthbert, 2008; valence ratings between 6.51 and 8.17) and 20 depicting spiders.[2] Images were 1,024 pixels × 768 pixels to fill the entire screen. Participants were told that (1) they could examine each picture for long as they wanted before advancing to the next on and (2) they would be asked questions about the pictures later on. The index of behavioral avoidance was the amount of time viewing spider pictures, controlling for viewing times of positive pictures. Short viewing times represent higher avoidance (cf. Knopf & Pössel, 2009).

Physiological measurements and processing. Physiological reactions were recorded via the Biopac MP36 system (Biopac Systems Inc., Goleta, CA) with data acquisition and processing performed using the AcqKnowledge 4.1.1 software (AcqKnowledge, 2010). To measure electrodermal activity (EDA), disposable electrodes (EL507, Biopac Systems Inc., Goleta, CA) coated with isotonic gel (GEL101, Biopac Systems Inc., Goleta, CA) were applied to distal phalanges of the second and third fingers of the nondominant hand. Before the electrode placement, the skin areas were cleaned with distilled water. EDA was recorded at a sampling rate of 1,000 Hz. Tonic and phasic signals were analyzed separately off-line. Phasic, skin conductance responses (SCRs) were isolated from the tonic, skin conductance levels using a high-pass filter (0.5 Hz) and then smoothed using a sliding mean of 250 samples. EDA data could not be analyzed for four participants due to high levels of noise in the signal.

Heart rates (HR) were recorded using a pulse plethysmogram (SS4LA, Biopac Systems Inc., Goleta, CA) transducer attached to the distal phalanx of the first finger of the nondominant hand. By the automatic detection of the HR waveform intervals between positive peaks, a new waveform representing beats per minute

[2] Positive pictures included the following: 1601, 1650, 1721, 1722, 1812, 2057, 2070, 2080, 5450, 5470, 5600, 5626, 5628, 5660, 5700, 5890, 5994, 7325, 8080, 8300.

(bpm) was derived off-line for each participant. These new waveforms were then visually inspected for any artifacts. Four participants (including two who had no usable EDA data) were not included in analyses involving HR because their HR waveforms fell outside the recommended range of 40 bpm to 180 bpm (cf. Arriaga, Esteves, Carneiro, & Monteiro, 2008).

SCR and HR data were extracted from the period during which spider and neutral images were presented. Additionally, an SCR was considered stimulus-specific (S.SCR) if its onset occurred within a latency window between 1 s and 5 s after image onset, and only if its amplitude exceeded 0.05 μSiemans.

Results

We first present the results for the full sample. Then we examine the question of whether these results vary between fast and slow respondents.

Impact of the fear induction on implicitly assessed and self-reported emotions. A mixed analysis of variance (ANOVA) examined differences in implicitly assessed emotions (within-subject variable) between the spider-fearful and control groups (between-subjects variable). The analysis revealed a significant Group × Implicit Emotion interaction, $F(3, 80) = 3.47$, $p = .020$, $\eta_p^2 = .12$. As evident in Figure 2A, compared with control participants, spider-fearful participants had higher implicit fear scores, $t(82) = 2.05$, $p = .044$, $d = 0.46$, 95% CI [0.04, 2.77], and lower implicit happiness scores, $t(82) = 2.77$, $p = .007$, $d = 0.61$, 95% CI [−2.03, −0.33]. No differences in other implicitly assessed emotions were significant (*p*s > .56).

Table 1 presents self-reported emotions. A mixed ANOVA indicated a significant Group × Self-Reported Emotion interaction, $F(3, 79) = 23.82$, $p < .001$, $\eta_p^2 = .48$. Compared with controls, spider-fearful individuals were more fearful, $t(81) = 7.77$, $p < .001$, $d = 1.73$, less happy, $t(81) = 3.76$, $p < .001$, $d = 0.82$, and angrier, $t(81) = 5.47$, $p < .001$, $d = 1.22$. The groups did not differ in self-reported sadness, $t(81) = 1.17$, $p = .25$, $d = 0.25$. As in prior work, the implicit task but not the self-report measure showed an emotion-specific profile. Additionally, independent-samples *t* tests showed that compared with controls, spider-fearful individuals rated spider images as more frightening ($M = 1.43$, $SD = 0.68$ vs. $M = 3.91$, $SD = 0.84$), $t(81) = 14.77$, $p < .001$, $d = 3.25$, and reported higher anxiety levels (on the BAI-Sp) in response to spider images ($M = 4.05$, $SD = 5.08$ vs. $M = 22.58$, $SD = 10.30$), $t(81) = 10.27$, $p < .001$, $d = 2.28$.

Criterion validity: behavioral and physiological indices. The crucial goal of this study was to examine the criterion validity of the implicit emotion-assessment task. To this end, we tested whether the implicit emotion scores would predict participants' physiological reactions and avoidance behavior.

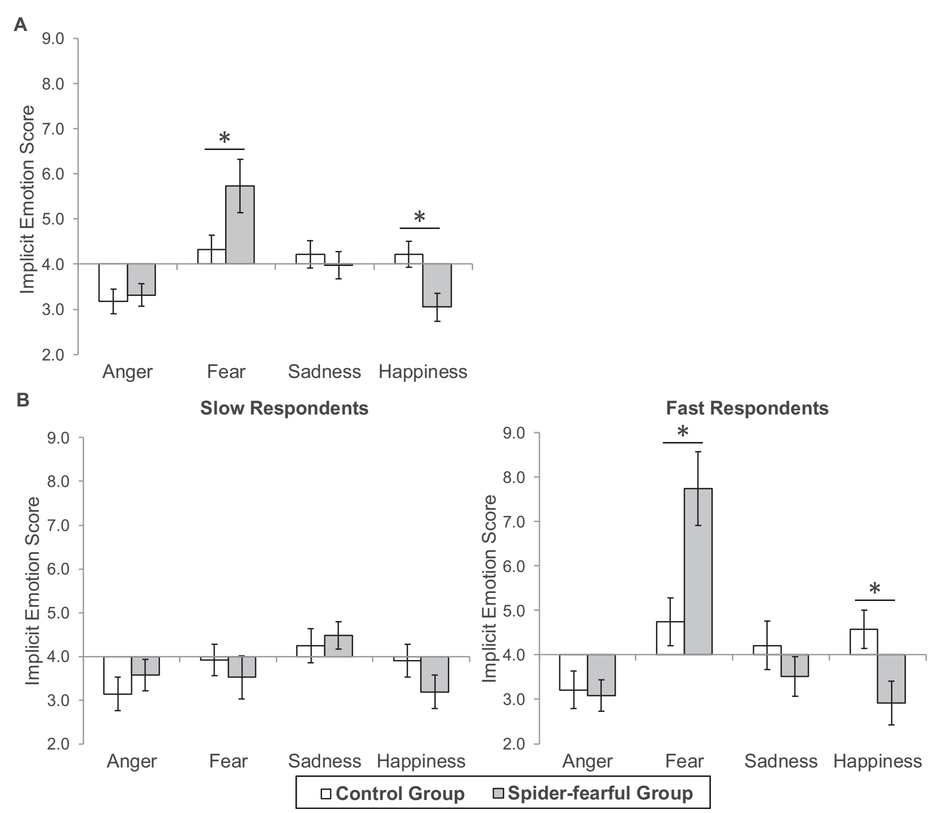

Figure 2. (A) Misattribution of emotions to abstract images as a function of the group. (B) Misattributions of emotions to abstract images for slow (left) and fast (right) respondents as a function of the group. Error bars represent standard errors of the means. By chance alone, each response of the implicit measure would, on average, be selected four times; thus, the horizontal axis crosses the vertical axis at 4. * $p < .05$.

Table 1
Means (and Standard Deviations) of Self-Reported Emotions in Studies 1 Through 3

Condition/group	Self-reported Anger	Fear	Sadness	Happiness
Study 1				
Control	**1.23** (0.35)	**1.24** (0.44)	1.53 (0.69)	**1.82** (0.89)
Spider-fearful	**2.04** (0.87)	**2.85** (1.24)	1.71 (0.76)	**1.25** (0.41)
Study 2				
Control	**1.40** (0.62)	**1.21** (0.40)	**1.39** (0.50)	2.38 (1.15)
Spider-fearful	**2.74** (0.97)	**3.22** (1.10)	**2.44** (1.11)	2.54 (1.15)
Study 3				
Relaxation	**1.14** (0.32)	**1.27** (0.55)	**1.70** (0.73)	**2.64** (1.10)
Sadness	**2.19** (0.98)	**2.60** (1.06)	**3.15** (1.05)	**1.14** (0.35)

Note. Means in boldface type indicate significant group differences at $p < .05$.

Electrodermal activity. The number of S.SCR occurrences and their amplitudes in response to spider and neutral images were square-root transformed to normalize these variables.[3] An analysis of covariance (ANCOVA; controlling for the number of S.SCRs to neutral images) indicated that spider-fearful participants (M = 7.59, SD = 6.27) experienced a greater number of S.SCR occurrences to spider images than did controls (M = 4.77, SD = 4.01), $F(1, 77) = 11.31$, $p = .001$, $\eta_p^2 = .13$. Similarly, the amplitudes of S.SCRs to spider images were higher among the spider-fearful individuals (M = 0.57, SD = 0.43) than among controls (M = 0.43, SD = 0.39) when controlling for the S.SCR amplitudes to neutral-images, $F(1, 77) = 4.32$, $p = .041$, $\eta_p^2 = .05$.

Table 2 reports correlational data relating implicitly assessed emotions to self-reported, behavioral, and physiological indices of spider phobia. These data support the criterion validity of the implicit emotion-assessment task. Implicitly assessed fear, unlike anger or sadness, predicted both the number and amplitudes of S.SCRs to spider images (controlling for the corresponding responses to neutral images). Additionally, even when controlling for self-reported fear, implicit fear scores continued to correlate with the number ($r = .33$, $p = .003$) and amplitudes ($r = .23$, $p = .048$) of S.SCRs, supporting incremental validity of the implicit task. Implicit happiness was negatively correlated with the number of S.SCRs to spider images.

HRs. HR data were normally distributed. As expected, controlling for HR levels in response to neutral images, the spider-fearful group (M = 85.39, SD = 10.99) evidenced significantly higher peak HRs to spider images than did the control group (M = 77.35, SD = 10.86), $F(1, 77) = 13.79$, $p < .001$, $\eta_p^2 = .15$. However, implicit emotion scores were uncorrelated with these HR data (see Table 2).

Avoidant behavior. Controlling for the viewing times of positive images, an ANCOVA indicated shorter viewing times of spider images (i.e., increased avoidance behavior) among spider-fearful individuals (M = 1.18s, SD = 1.15) than among control individuals (M = 3.50s, SD = 2.51), $F(1, 80) = 51.52$, $p < .001$, $\eta_p^2 = .39$.[4] Moreover, Table 2 shows that the higher participants' implicit fear (and the lower implicit happiness scores), the less time they spent viewing spider images (controlling for positive-image viewing times). However, these correlations were only marginally significant in the full sample.

Construct validity. The convergent and discriminant validity of the implicit emotion-assessment task was examined by relating implicitly assessed emotions to the self-reported indices of spider phobia: (1) an overall fear of spiders (FSQ scores), (2) fright ratings of spider pictures, and (3) levels of anxiety in response to spider pictures (BAI-Sp scores). The implicit task evidenced both convergent and discriminant validity in that the implicit fear, but not anger or sadness, correlated positively with fright ratings and reported anxiety to spider pictures (BAI-Sp scores). Importantly, the implicit task evidenced incremental validity such that correlations between implicit fear and BAI-Sp scores were significant even after controlling for self-reported fear ($r = .25$, $p = .025$). However, the implicit emotions were not associated with the FSQ scores in the full sample.

Effect of response times on the implicit emotion-assessment task. Figure 2B presents implicit emotion scores among slow and fast respondents (defined by the median split of response times) and shows that the speed of responding affected the implicit measure's ability to detect emotions. A three-way mixed ANOVA examining the effects of response speed and group on implicitly assessed fear and happiness revealed a significant three-way interaction, $F(1, 80) = 6.95$, $p = .010$, $\eta_p^2 = .08$. Among fast respondents, the Group × Implicit Emotion interaction was significant, $F(1, 40) = 10.85$, $p = .002$, $\eta_p^2 = .21$. In this subsample, control and spider-fearful groups differed in implicit fear, $t(40) = 2.89$, $p = .006$, $d = 0.92$, 95% CI [0.90, 5.10], and happiness, $t(40) = 2.49$, $p = .017$, $d = 0.78$, 95% CI [−0.31, −3.02], with large effect sizes. In contrast, the Group × Implicit Emotion interaction was not significant among slow respondents, $F(1, 40) = 0.11$, $p = .745$, $\eta_p^2 = .00$, and thus spider-fearful participants and controls had virtually the same implicit emotion scores (ps > .18). Analyses involving implicitly assessed anger and sadness yielded nonsignificant interactions and nonsignificant effects of the group and response times (all ps > .21).

The lower section of Table 2 shows that, among fast respondents, implicitly assessed fear correlated significantly and in the expected direction with all self-reported indices of spider phobia and with avoidant behavior. In contrast, among slow respondents, all these correlations were nonsignificant.

A similar pattern of findings emerged for the psychophysiological measures. Partial correlations between implicit fear scores and the number of S.SCR occurrences to spider images ($r = .59$, $p < .001$; controlling for the corresponding responses to neutral images) were significant only among fast respondents. Even after controlling for self-reported fear, this correlation remained significant ($r = .46$, $p = .004$, respectively). Last, the correlation between implicit fear and peak HRs was positive (although only marginally significant) in the fast-responding group, whereas it was near zero in the slow-responding group.

[3] For clarity, means and standard deviations of untransformed data are provided.

[4] In both Studies 1 and 2, the two variables (i.e., viewing times of spider images and viewing times of positive images) were square-root transformed to correct for skewness; for clarity, means and standard deviations of untransformed data are provided.

Table 2
Correlations of Implicitly Assessed Emotions With Self-Reported, Behavioral, and Physiological Indices of Spider Phobia

Implicit emotion	FSQ score	Fright rating	BAI-Sp	Avoidance behavior$_{sqrt}$	S.SCRs		Peak heart rates
					Number$_{sqrt}$	Amplitude$_{sqrt}$	
Anger	.05	−.03	.07	−.10	−.18	.10	−.02
Fear	.17	**.24***	**.31****	−.17	**.38*****	**.26***	.10
Sadness	−.05	−.07	−.10	−.04	−.04	−.08	−.14
Happiness	**−.28*****	**−.28***	**−.31****	.21†	**−.30****	−.15	**−.24***
				Slow respondents			
Anger	.08	.02	.17	−.17	−.12	.20	−.09
Fear	−.15	−.08	−.05	.02	.24	.28†	−.01
Sadness	.07	.18	.10	−.11	.05	−.05	.08
Happiness	−.19	−.28†	−.22	.18	−.27†	−.07	**−.34***
				Fast respondents			
Anger	.03	−.07	.01	−.01	**−.32***	.11	.10
Fear	**.35***	**.43****	**.43****	**−.43****	**.59*****	.26	.28†
Sadness	−.13	−.23	−.19	.03	−.14	−.08	−.24
Happiness	**−.36***	−.28†	**−.37***	.25	**−.35***	−.18	−.16

Note. Values with the "sqrt" subscript are square-root transformed variables. FSQ = Fear of Spiders Questionnaire; BAI-Sp = Beck Anxiety Inventory administered with "while viewing spider images" instructions (instead of "in the last week, including today"); S.SCR = specific skin conductance response. Correlations in boldface type are significant at $p < .05$.
† $p < .10$. * $p < .05$. ** $p < .01$. *** $p < .001$.

Discussion

The present results confirm prior findings indicating that an implicit measure of emotion based on fast evaluations of abstract images can assess and differentiate among distinct emotional states (Bartoszek & Cervone, 2017). The study also provides novel evidence that these evaluations can predict physiological and behavioral reactions to emotion-evoking stimuli.

Overall, compared with controls, spider-fearful individuals rated more painting images as expressing fear and fewer images as expressing happiness. As predicted, these profiles of implicitly assessed emotions varied between fast and slow respondents. Specifically, the group differences in implicitly assessed fear and happiness were significant and of large effect sizes only among fast respondents but virtually nonexistent among slow respondents.

Consistent with the dual-process framework, coherence between implicitly assessed emotions and other indices of emotional responding also depended on the speed of responding to the implicit task items (e.g., Evers et al., 2014). Among fast responding participants, the implicit-assessment task demonstrated good convergent and discriminant validity in that implicit fear, but not anger or sadness, robustly correlated with (1) all three self-report indices of spider phobia, (2) avoidance behavior, and (3) the number of S.SCR. The correlation between implicit fear and the number of S.SCR remained significant even after controlling for self-reported fear supporting the incremental validity of the task. Although correlations of implicit fear with S.SCR amplitudes and HR levels were not significant in this subsample, correlations of such magnitudes (i.e., r range = .26–.28) would be significant in our full sample (at $p < .012$–.020). In stark contrast, in the slow responding subgroup, all these correlations were nonsignificant, and three were near zero. Accordingly, when participants respond slowly, the implicit emotion-assessment task does not appear to be a valid measure of emotions.

Study 2

Study 1 revealed an association between response speed and reliance on emotion-based processes. The results, however, did not clarify the direction of this association. One possibility is that fast responding increases one's reliance on heuristic, Type I processes while precluding the use of deliberate, Type II processes. An alternative is that a third variable—a stable individual difference—influences both response speed and ratings of the ambiguous images. For example, emotional experiences might be more salient and/or intense for some participants allowing them to more easily and quickly access these emotions when evaluating ambiguous stimuli (Greifeneder, Bless, & Pham, 2011; individual-differences hypothesis).

To test these competing hypotheses and to obtain stronger evidence of the role of response speed in assessing emotions implicitly, we imposed time pressure on the implicit measure. Specifically, participants had to rate each abstract image within five seconds—the median response time to the implicit measure items across our studies. Imposing time pressure in responding should increase reliance on the fast, Type I processes supporting the dual-process hypothesis; however, such a time restriction would not be expected to affect the salience or intensity of emotional experiences (individual-differences hypothesis).

Our prior studies employed both black-and-white and color abstract images. Color itself might convey emotional information and might make these images less ambiguous. Therefore, (using the Flame Painter 3 software, Escape Motions, s.r.o.) we created a new set of ambiguous images presenting black-and-white abstract expressionist artworks and pretested them in an online study (N = 189). Of 60 pretested images, we selected 25 images that did not elicit a disproportionate choice of one response. On average, across all 25 images, anger was attributed by 19.91% of people, fear by 21.10%, sadness by 19.79%, and happiness by 22.71%.

We expected that these modifications to the implicit emotion-assessment task would enhance its validity so that it can serve as an implicit measure of distinct emotional states. To examine its validity, as in Study 1, we exposed controls and spider-fearful individuals to spider images. We expected that the two groups would differ in implicit fear scores, fright ratings of spider images, and behavioral avoidance. Importantly, we expected that the implicit fear would correlate with participants' self-reported and behavioral indices of spider phobia.

Method

Participants. Participants ($N = 98$; 52 women and 46 men; $M_{age} = 34.65$, $SD = 11.90$), recruited via Amazon's Mechanical Turk (MTurk) website, included 47 control individuals (FSQ $\leq$ 10; $M = 3.51$, $SD = 3.65$) and 51 spider-fearful individuals (FSQ $\geq$ 70; $M = 88.27$, $SD = 14.85$). Participants were 60% (59) White, 6% (6) Black, 27% (26) Asian, 4% (4) Latino, and 3% (3) other.

Materials and measures. The behavioral avoidance measure, FSQ, PANAS-X, and fright ratings of spider images were administered as in Study 1. The instructions of the implicit measure of distinct emotional states used in this study informed participants that (1) they "will see paintings of *digital abstract expressionism* . . . a style of painting in which artists express their emotions using digital media" and (2) their "task will be to judge what emotion (if any) the artist tried to express in each painting." Next, they were briefly informed about the timing of the measure items and structure of the test.

On each trial of the implicit measure, an abstract image was displayed for 5 s with the five response options (i.e., *anger*, *fear, happiness*, *sadness*, *none*) being clickable during the last 3 s of the trial (see Figure 3). Once the participant chose one of the options or the 5 s elapsed, the next trial was presented, and the cycle continued automatically until all 25 abstract images were presented. The decision to provide participants with up to 5 s was driven by the data from our previous studies showing that the median response time to the implicit measure items was approximately 5 s.

The composite scores of the implicit measure were derived from the ratings of the last 20 abstract images (actual trials). The first five abstract images were treated as practice trials although, to respondents, they were indistinguishable from the remaining trials. If no response option was selected during the 3-s time window, that actual trial's datum was coded as missing. To adjust for missing data, the emotion scores for each participant were multiplied by the ratio of the maximum possible number of responses (i.e., 20) to the number of provided responses (this ratio equals 1 for those with no missing data on the implicit measure). However,

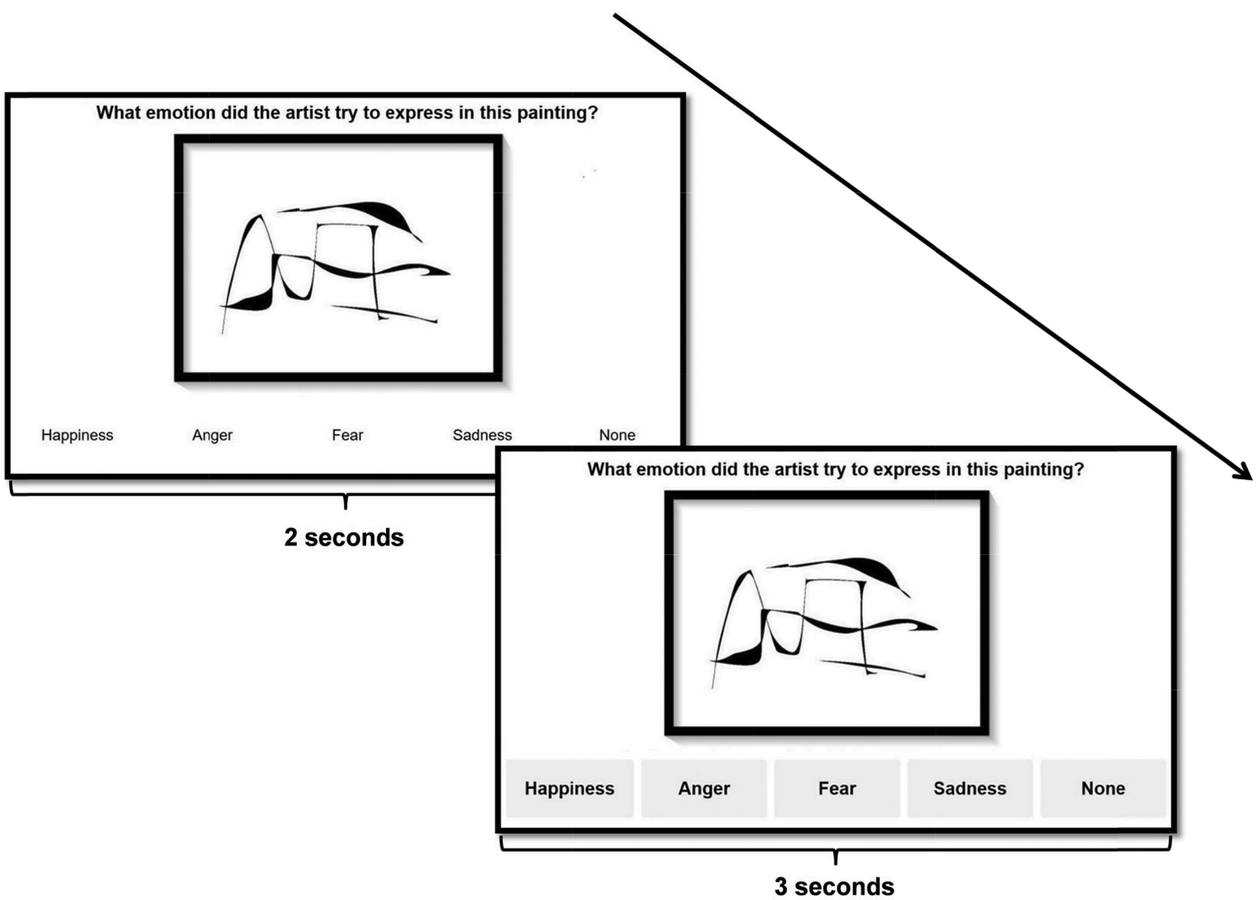

Figure 3. Illustration of a single trial of the implicit measure of distinct emotional states.

six controls and seven spider-fearful participants (13.3%) who rated fewer than 75% (<15) of the actual-trial images were not included in the analyses.

Procedure. The study was programmed in Qualtrics (Provo, UT) and posted via the MTurk website, with a restriction to only those who had at least an 80% approval rate for all their previous MTurk tasks. All participants consented to the procedures. We used the FSQ as a screening tool and paid $0.05 for its completion. Eligible respondents (with FSQ scores ≤10 or ≥70) were automatically offered participation in the main part of the study for an additional $0.60.

Participants first completed the implicit measure with imposed time pressure. As in Study 1, a 1-s spider image preceded each abstract image, and participants were instructed to rate the content of only the abstract images ignoring the spider ones. After completing the measure, participants reported whether images were displayed properly on their screens. They then completed the behavioral avoidance task, followed by PANAS-X and fright ratings of spider images. After providing demographic information, they were debriefed.

Results

Impact of the fear induction on implicitly assessed and self-reported emotions. We first examined the pattern of missing data on the implicit measure's practice and actual trials. The five practice trials were left unrated within the 3-s time window by 47, 28, 11, 22, and 13% of participants, respectively. As to the actual trials, 41% of participants rated all 20 images. Overall, participants failed to rate 7% (119) of the (85 Participants × 20 Images) 1,700 actual trials within the 3-s time window. The control participants (M = 1.29, SD = 1.47) and spider-fearful participants (M = 1.51, SD = 1.62) did not differ in the number of unrated abstract images, $t(83) = 0.67$, $p = .503$, $d = 0.15$.

Figure 4 shows that, as in Study 1, the implicit measure captured the predicted effects of the fear induction on emotions. The Group × Implicit Emotion interaction was significant, $F(3, 81) = 14.27$, $p < .001$, $\eta_p^2 = .35$. Compared with the control group, the spider-fearful group evidenced elevated implicit fear scores, $t(83) = 6.20$, $p < .001$, $d = 1.35$, 95% CI [2.49, 5.06], and diminished implicit happiness scores, $t(83) = 4.76$, $p < .001$, $d = 1.03$, 95% CI [−3.60, −1.39]. The groups did not differ in implicitly assessed anger or sadness ($ps > .59$).

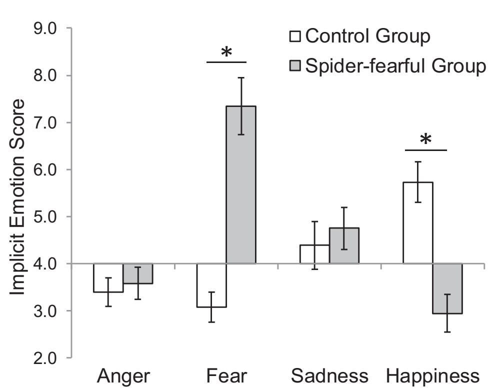

Figure 4. Misattribution of emotions to abstract images as a function of the group. Error bars represent standard errors of the means. By chance alone, each response of the implicit measure would, on average, be selected four times; thus, the horizontal axis crosses the vertical axis at 4. * $p < .05$.

A mixed ANOVA also found a significant Group × Self-Reported Emotion interaction, $F(3, 81) = 14.40$, $p < .001$, $\eta_p^2 = .35$ (see Table 1). Compared with control participants, those afraid of spiders were more fearful, $t(83) = 11.16$, $p < .001$, $d = 2.43$, sadder, $t(83) = 5.63$, $p < .001$, $d = 1.23$, and angrier, $t(83) = 7.51$, $p < .001$, $d = 1.63$. There were no group differences in self-reported happiness, $t(83) = 1.17$, $p = .25$, $d = 0.14$. Additionally, an independent samples t test indicated that compared with control participants (M = 1.62, SD = 0.70), spider-fearful participants found the spider images to be more frightening (M = 3.67, SD = 0.89), $t(83) = 11.82$, $p < .001$, $d = 2.56$.

Construct and criterion validity. The correlational data in Table 3 show that implicitly assessed fear predicted participants' self-reported indices of spider phobia (i.e., FSQ scores and fright ratings of spider images). Table 3 also indicates that implicit fear was predictive of avoidance behavior, which was heightened (i.e., viewing times of spider images were shorter) among spider-fearful individuals (M = 0.84 s, SD = 0.18) in comparison to controls (M = 1.43 s, SD = 0.57; controlling for viewing times of positive images), $F(1, 82) = 37.15$, $p < .001$, $\eta_p^2 = .31$. The correlation between implicit fear scores and avoidant behavior remained significant even when controlling for self-reported fear ($r = -.27$, $p = .013$).

In sum, when time pressure requires all participants to rate the new abstract images quickly, implicitly assessed fear correlated with self-reported and behavioral indices of spider phobia. However, were these correlations larger than the corresponding correlations in Study 1, which included both fast and slow respondents rating the old abstract images? One-tailed Fisher r-to-z transformations showed this to be the case for all three correlations between implicitly measured fear and the other indices of spider phobia: (1) FSQ scores ($z = 2.67$, $p = .004$), (2) fright ratings of spider images ($z = 1.94$, $p = .026$), or (3) behavioral avoidance ($z = 2.08$, $p = .019$).

Discussion

The results indicated that including new, pretested abstract images and imposing time pressure in rating these images enhanced the sensitivity as well as construct, criterion, and incremental validity of the implicit measure of distinct emotional states (cf. Hu et al., 2014). As in our prior research, the implicit measure showed the expected differences between control and spider-fearful groups in implicitly assessed fear and happiness. However, group differences in the target emotion (i.e., fear) were of large effect size ($d = 1.35$) as compared with the medium effect size ($d = 0.46$) obtained in Study 1. Moreover, the correlations of implicit fear with other indices of spider phobia: self-reported fear of spiders, fright ratings of spider images, and avoidance behavior, were all significant and significantly larger than the corresponding correlations in Study 1. Importantly, implicit fear predicted participants' avoidance behaviors even after controlling for self-reported fear. Altogether, when participants have to respond quickly to the implicit measure items, the measure emerges as a more sensitive and valid index of emotional states.

Table 3
Correlations of Implicitly Assessed Emotions With Self-Reported and Behavioral Indices of Spider Phobia

Implicit emotion	FSQ score	Fright rating	Avoidance $behavior_{sqrt}$
Anger	.06	.13	$-.22^{\dagger}$
Fear	**.53*****	**.50*****	**−.46*****
Sadness	.08	.04	.00
Happiness	**−.48*****	**−.48*****	**.42*****

Note. Values with the "sqrt" subscript are square-root transformed variables. FSQ = Fear of Spiders Questionnaire. Correlations in boldface type are significant at $p < .05$.
† $p < .10$. *** $p < .001$.

These findings are inconsistent with the individual-differences hypothesis. According to this hypothesis, a stable individual difference—for example, participants' ability or tendency to access and use their emotions in judgment—affected both the speed and contents of their evaluations of abstract images in Study 1. If this hypothesis were true, increasing the speed of participants' responses would, if anything, reduce participants' ability to pay attention to their emotional states and thus weaken the robustness of the implicit-measure results—an outcome opposite to the one obtained in this study.

In contrast, the results do align with the dual-process hypothesis and with previous studies (e.g., Finucane et al., 2000; Hu et al., 2014; Siemer & Reisenzein, 1998) showing that imposing time pressure increases one's use of emotions in judgments. That is, when evaluating the ambiguous stimuli quickly, participants more heavily rely on automatic and emotion-based Type I processes as opposed to analytic and deliberate Type II processes. This increased reliance on emotions improves the validity of the implicit measure of emotions.

The limitation of this novel implicit measure involves a relatively high amount of missing data due to imposed time pressure. One of the goals of the next study is to curtail this limitation.

Study 3

Study 2 showed that imposing time pressure on ratings of the abstract images increased the validity of the implicit measure of distinct emotional states. We argued that participants are more likely to rely on emotion-based (Type I) processes when responding quickly, whereas slow respondents employ analytical (Type II) processes (dual-process hypothesis). However, another possibility related to the dynamic and fleeting nature of emotions remains untested. Specifically, by the time one responds to an implicit measure item, the intensity of the emotional state elicited by the preceding emotion-evoking stimulus could decrease merely due to the passage of time (passage-of-time hypothesis). For example, in Study 1, a participant who rated an abstract image 9 s after the presentation of a spider image might have experienced a greater decline in a given emotional state (e.g., fear) as compared with an individual who responded within 3 s.

Note that akin to the dual-process hypothesis, the passage-of-time hypothesis presumes that fast respondents rely on emotions in their ratings of the abstract images. The two hypotheses differ in their explanations as to why ratings provided by slow respondents do not reflect the effects of emotion-inducing procedures: time-related decrease in emotional intensity versus reliance on nonemotional Type II processes.

It is also conceivable that when responding quickly, participants do not have enough time to evaluate the abstract images and thus *intentionally* use their (1) emotional states or (2) knowledge about the emotional value of the manipulation procedure. Such an explicit use of emotions would undermine the implicit nature of the measure. One strategy to examine this further would be to ask participants whether they were aware of the effects of the emotion-manipulation procedures on their ratings. However, such a leading question could result in retrospective confabulations in that even unaware participants could, with hindsight, realize the influence of the manipulations and thus respond affirmatively (Payne & Lundberg, 2014). A less biased approach would be to ask participants an open-ended question about their general strategies of rating the abstract images. If participants are intentionally using their emotions or the knowledge about the effects of emotion-manipulation procedures, their answers to such an open-ended question should reflect these explicit strategies. However, if participants indicate that they rated the images by evaluating their contents without a reference to their own emotions or emotion-induction procedures, then these answers would support the implicit nature of the measure.

To better understand the mechanisms underlying responses on the implicit measure, Study 3 tested whether fast and slow respondents would evidence different profiles of implicitly assessed emotions when the time between the emotion induction and ratings of the abstract images remained constant. We also used an emotion manipulation method other than the presentation of static images. To this end, participants first listened to a story that induced either sadness or relaxation (cf. Bartoszek & Cervone, 2017). Next, participants were assigned randomly to either a slow-pace or a fast-pace condition, in which they viewed each abstract image for 6 s or 2 s, respectively, and then had 3 s to rate it. As depicted in Figure 5, in an attempt to equalize the completion time of the implicit measure between the conditions, a blank screen was presented for approximately four seconds before each abstract image in the fast-pace condition. Therefore, compared with the fast-pace condition participants, those in the slow-pace condition had three times as much time (i.e., 6 s vs. 2 s) to examine each abstract image before rating it; however, in both conditions, participants spent between 6 s and 9 s on each trial. Thus, the description of the (fast vs. slow) pace refers to the presentation time of each trial rather than the completion time of the entire measure. Last, participants were asked about their strategies of rating the abstract images.

We expected a significant interaction between the emotion manipulation and the response-time manipulation, with the effects of the emotion manipulation on implicitly assessed sadness and happiness being evident in the fast-pace but not the slow-pace condition. As in Studies 1 and 2, we did not expect significant main effects or interactions on the nontarget emotions of anger and fear.

Method

Participants. Participants ($N = 286$; 185 women and 101 men; $M_{age} = 18.85$ years, $SD = 1.41$) were recruited from an undergraduate introductory psychology class. They were 30% (85)

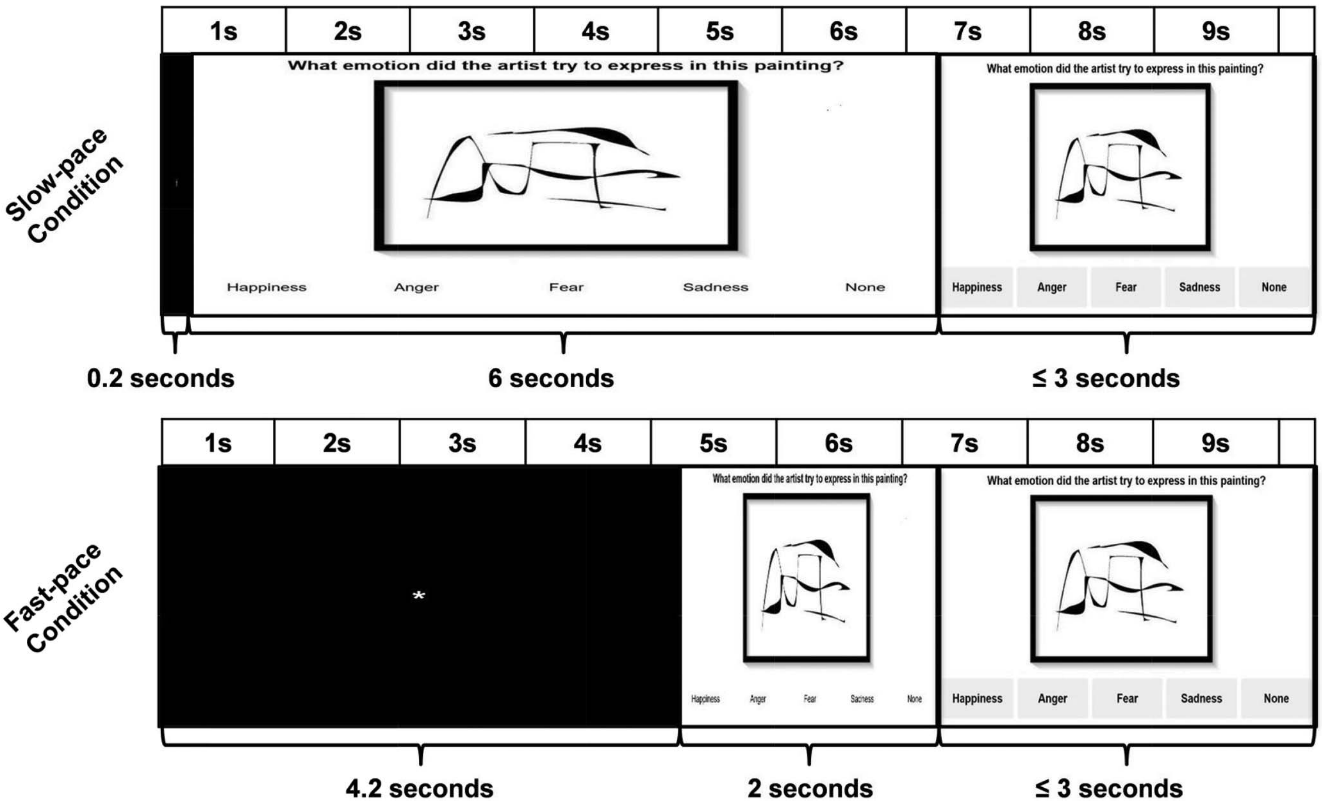

Figure 5. Illustrative representation of the timing of the implicit measure trials in the slow-pace and fast-pace conditions.

White, 8% (24) Black, 29% (82) Asian, 28% (80) Latino, and 3% (8) other; 2% (7) of the participants did not report their race.

Procedure. Upon arrival at the laboratory, participants consented to the procedures (which resembled those in Experiment 1 of Bartoszek & Cervone, 2017). First, to hide the purpose of the research, the study was presented as an investigation of how visual information interferes with auditory information. Subsequently, by random assignments, participants listened via headphones to either a sadness-evoking ($n = 143$) or a relaxation-evoking ($n = 143$) story for approximately 5.5 min. One participant who fell asleep during the relaxation-inducing story was excluded from the analyses. Next, participants were randomly assigned to complete a version of the implicit measure of distinct emotional states with fast-pace ($n = 143$) or slow-pace ($n = 143$) trials.

As shown in Figure 5, in both pace conditions, a blank screen with a fixation point preceded each trial of the measure. The presentation time of the fixation point and the trials differed between the two pace conditions. Participants viewed the fixation point for 4.2 s in the fast-pace condition or 0.2-s in the slow-pace condition. They then viewed an abstract image for 2 s (fast-pace) or 6 s (slow-pace); participants could not yet rate the image at that time, as the response options were not clickable. Last, participants in both conditions had up to 3 s to rate the abstract image.

Practice trials again preceded the actual trials, but because missing data considerably decreased and plateaued after the first four practice items in Study 2, we reduced their number from five to four. Additionally, we attempted to reduce the number of missing data points: Whenever participants failed to respond during the second, third, or fourth practice trial, a "try to respond faster" message was displayed on the screen for 3 s.

The composite scores of the implicit measure were derived from the ratings of the last 20 images (thus excluding the practice trials) and computed precisely as in Study 2. Ten (3.5%) participants who rated fewer than 75% (<15) of the actual-trial images were not included in the analyses.

Participants also reported their emotions via selected subscales of the PANAS-X (as in Study 1 and 2). They were then asked, "What was your strategy in rating the abstract paintings? That is, how did you decide which emotion to select?" and answered in an open-ended response format. Last, they provided basic demographic information. All participants were debriefed at the end of the study.

Results

We first examined the amount of missing data on the implicit measure of distinct emotional states. The four practice trials of the measure were left unrated within the 3-s time window by 54%, 25%, 13%, and 5% of participants, respectively. Of the actual trials, 58% of participants rated all 20 images. Overall, participants failed to rate only 3.3% (181) of the (275 Participants × 20 Images) 5,500 actual trials within the 3-s time window. The number of missed trials did not differ as a function of the emotion condition ($M = 0.65$, $SD = 0.93$ vs. $M = 0.66$, $SD = 1.05$), F(1,

271) = 0.00, p = .952, η_p^2 = .00, the pace condition (M = 0.68, SD = 0.98 vs. M = 0.64, SD = 1.00), F(1, 271) = 0.12, p = .735, η_p^2 = .00, or the interaction between these two conditions, F(1, 271) = 0.09, p = .763, η_p^2 = .00.

Figure 6 displays our primary dependent measure, the degree to which participants attributed emotions to the abstract images, as a function of the group. As expected, listening to the sadness-inducing story, as opposed to the relaxation-inducing story, increased implicit sadness and lowered implicit happiness; however, this was the case only for participants who completed the implicit measure with the fast-pace (rather than the slow-pace) trials. Statistical analyses confirmed this pattern of results. A three-way mixed ANOVA examining the effects of the emotion-induction procedure and the timing-manipulation on the levels of implicitly assessed sadness and happiness revealed a significant three-way interaction, F(1, 271) = 6.18, p = .014, η_p^2 = .02. As expected, follow-up analyses showed that among individuals who had little time to view the abstract images (fast-pace condition), the Emotion Condition × Implicit Emotion interaction was significant, F(1, 135) = 10.57, p = .001, η_p^2 = .07. In the fast-pace condition, participants who listened to the sadness-inducing story rated more images as expressing sadness, t(135) = 2.56, p = .012, d = 0.44, 95% CI [0.20, 1.56], and fewer images as expressing happiness, t(135) = 2.82, p = .006, d = 0.49, 95% CI [−1.87, −0.33], than did those who listened to the relaxation-inducing story. In contrast, the two-way Emotion Condition × Implicit Emotion interaction was not significant among those who spent relatively more time viewing the abstract images (slow-pace condition), F(1, 136) = 0.01, p = .910, η_p^2 = .00. In the slow-pace condition, the sadness and relaxation groups did not differ in implicitly assessed sadness, t(136) = 1.70, p = .091, d = 0.29, 95% CI [−0.08, 1.02], or happiness, t(136) = 1.29, p = .198, d = 0.22, 95% CI [−0.28, 1.35]. Last, a three-way ANOVA examining implicitly assessed anger and fear yielded neither significant interactions nor other significant effects of the emotion induction or timing manipulation (all ps > .501).

To examine whether participants were aware of the influences of their emotions evoked by the story on their evaluative judgments, two investigators independently coded participants' answers about participants' strategies of rating the images. Of the 275 participants, only eight (2.9%) mentioned relying on the initial story or the resulting emotions as the basis for evaluating the affective content of the images. Three of the eight participants were in the fast-paced condition (one in the relaxation and two in the sadness conditions) and five were in the slow-paced condition (three in the relaxation and two in the sadness conditions). The remaining participants wrote that they rated the images with various strategies, all of which were unrelated to the story or the induced emotions. For example, participants indicated that they rated the images by trying to analyze their contents (e.g., "how thick or thin the paint strokes were"), putting themselves "in the painter's position" and thinking "about how I would perceive the painting," considering "whatever emotion that came to me from that picture," or choosing randomly and/or based on "the first instinct."

To ascertain that the responses of the eight participants did not drive the primary effects, we repeated the analyses involving implicitly assessed emotions after excluding these participants' data. The pattern of results remained the same. We found a significant three-way interaction, F(1, 263) = 5.49, p = .020, η_p^2 = .02. The Emotion Condition × Implicit Emotion interaction was also significant in the fast-pace condition, F(1, 132) = 9.09, p = .003, η_p^2 = .06, and not in the slow-pace condition, F(1, 131) = 0.03, p = .867, η_p^2 = .00. Once again, in this fast-pace condition, the emotion-manipulation groups differed in implicitly assessed sadness, t(132) = 2.45, p = .015, d = 0.42, 95% CI [0.16, 1.52], and happiness, t(132) = 2.60, p = .010, d = 0.45, 95% CI [−0.24, −1.80].

A mixed ANOVA also examined the effects of emotion manipulation on the four self-reported emotions and found a significant Emotion Condition × Self-Reported Emotion interaction, F(3, 271) = 140.93, p < .001, η_p^2 = .61 (see Table 1). Compared with participants in the relaxation condition, those who listened to the sadness-inducing story reported higher levels of sadness, t(273) = 13.31, p < .001, d = 1.60, anger, t(273) = 11.85, p < .001, d =

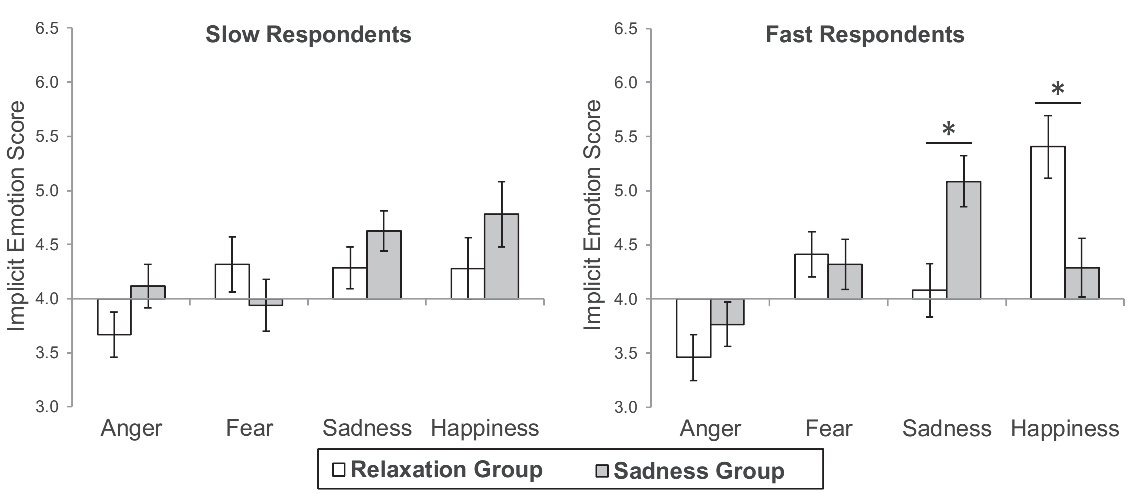

Figure 6. Misattribution of emotions to abstract images as a function of the group. Error bars represent standard errors of the means. By chance alone, each response of the implicit measure would, on average, be selected four times; thus, the horizontal axis crosses the vertical axis at 4. * p < .05.

1.44, and fear, $t(273) = 12.97$, $p < .001$, $d = 1.56$, as well as lower levels of happiness, $t(273) = 15.34$, $p < .001$, $d = 1.85$.

Discussion

By manipulating response times, this study further elucidated the mental processes underlying evaluations of ambiguous stimuli in general and responses to the implicit emotion measure items in particular. When people had little time to evaluate ambiguous stimuli such as the abstract images, they appeared more likely to rely on their gut feelings (Type I processes). Therefore, in the fast-pace condition, the implicit measure revealed expected elevations in sadness and decreases in happiness among participants who listened to the sadness-evoking story as opposed to the relaxing story. In contrast, when participants had more time to inspect ambiguous stimuli, they should be more likely to use "cold" systematic (Type II) processes and less likely to rely on their emotions in judgments. Correspondingly, in the slow-pace condition, the implicit measure did not index participants' emotional states.

A notable aspect of the study design was the addition of the 4-s intertrial pause in the fast-pace condition so that all participants completed the implicit measure in a similar amount of time. Therefore, the lack of group differences in implicitly assessed emotions among the slow-pace participants cannot be attributed merely to a time-related decrease in emotional intensity (passage-of-time hypothesis). Rather, the results remain consistent with the notion that those in the slow-pace condition relied on the "cold" Type II processes (dual-process hypothesis).

People appear to rate the images without realizing that their emotions influence these ratings. When asked how they had selected emotions when rating the images, only about three percent of people referred to the initial story or the induced emotions. After excluding these participants, the pattern of results remained unchanged. This is consistent with prior research (Study 2 of Bartoszek & Cervone, 2017 featuring an anger induction) in which only manipulation-unaware participants were included in the analyses. In the current study, most participants (97.1%) said they analyzed the contents of the images or chose randomly. This supports the implicitness of the measure, as misattributing one's emotions when rating the ambiguous stimuli does not seem to rely on the explicit use of one's emotions.

The secondary goal of this study was to reduce the number of missing data points on the implicit measure. To this end, a "Try to respond faster" message followed practice trials that participants failed to rate. Consequently, compared with 13% of participants in Study 2, only 3.5% of participants in this study failed to rate more than five actual-trial images. The remaining participants left 3% of the images unrated in this study as compared with 7% of the images in Study 2. Thus, the number of missing data decreased by more than half compared with Study 2. It is premature, however, to argue with certainty what led to this reduction, as the study involved a combination of new elements such as the induction of low arousal emotion of sadness and timing manipulations of the trials (although the amount of missing data was similar in the fast-pace and slow-pace conditions). Future studies should further examine the extent of missing data on this implicit measure.

General Discussion

The present results, along with those presented previously (Bartoszek & Cervone, 2017), lay the foundation for a novel assessment tool, namely, an Implicit Measure of Distinct Emotional States (IMDES) in which participants evaluate the emotional content of ambiguous abstract images. The three studies reported here supported the validity and specificity of the IMDES. In each study, the implicit measure revealed elevations in emotions targeted by the emotion-induction procedures but no elevations in nontarget emotions. As predicted by the feelings-as-information and dual-process frameworks, these changes were evident among fast, but not slow, responding participants whether the variations in response times occurred spontaneously (Study 1) or as a result of experimental manipulations (Studies 2 and 3). Therefore, the studies highlight that responding under time pressure is key to enhancing the validity of implicit methods for assessment of affect and emotions.

Correlational data lead to similar conclusions. As in prior studies (Bartoszek & Cervone, 2017), results supported the construct validity of the IMDES in that implicitly assessed fear predicted self-reported indices of spider phobia. In addition to prior findings, the current results supported the implicit measure's criterion validity in that misattributions of fear predicted participants' avoidance behaviors and skin conductance responses to spider images. Even after controlling for self-reported fear, implicitly assessed fear uniquely predicted skin conductance responses and self-reported anxiety supporting the incremental validity of the IMDES. The implicit measure also evidenced excellent specificity in that the target emotion (i.e., fear), but not anger or sadness, correlated positively with self-reported, behavioral, and physiological indices of fear. This indicates that the measure is capable of not only assessing but also differentiating emotions of the same valence.

Inducing negative emotions not only increased levels of the corresponding negative emotional states but also decreased implicitly measured happiness. These findings are consistent with theoretical models, such as the circumplex model of affect, that conceptualize affective dimensions as bipolar (Russell, 2003). Based on the circumplex model, a negative emotion induction would be expected to shift a participant's affect away from the positive end of the valence dimension. Consequently, through affect-as-information processes, participants would be expected to rate fewer abstract images as expressing happiness.

The IMDES's documented ability to assess each of a variety of distinct emotional states including anger, fear, and sadness is particularly notable in that similar findings with other implicit measures are lacking. An adaptation of the IPANAT designed to measure distinct emotions, the IPANAT-DE (Bode, 2014), showed that the presentation of primes of sad or happy faces resulted in increased levels of sadness or happiness, respectively, but no elevations in other emotions. However, although the IPANAT-DE indicated reduced happiness in response to angry face primes, the test did not reveal changes in negative emotions as a result of these primes (Bode, 2014; also see Quirin & Bode, 2014). Another task, the "emotion misattribution" procedure (EMP), revealed that after seeing a picture of an emotional face, participants were more likely to rate neutral-face pictures as displaying the emotion presented earlier (Rohr, Degner, & Wentura, 2015). Given that facial expression of anger (a threatening stimulus) could likely elicit fear as opposed to anger, the authors suggested that "cold" semantic priming rather than affective processes produced the effects on the EMP (cf. Blaison, Imhoff, Hühnel, Hess, & Banse, 2012). Recently, a novel discrete emotion Affect Misattribution Procedure (AMP), revealed that after seeing pictures normed to evoke fear, disgust, lust, or happiness, participants rated more Chinese ideographs as related to that emotion (Lee et al., 2020). However, the ability of the discrete emotion AMP to assess commonly occurring emotions such as anger and sadness is yet to be established.

The long-term aim of our program of research on the IMDES is not merely to devise a measure that can detect variation in distinct emotions validly; we have also aimed to devise a measure that is practical. Basic and applied researchers, as well as practitioners, who would benefit from an implicit emotion measure, commonly need assessment procedures that can be administered easily and rapidly. Creating a measure that is simultaneously valid and practical is a challenge that past research on implicit emotion assessment has not fully overcome. As Lee and colleagues (2020) noted in describing their method, "the AMP typically takes longer to complete that self-report measures of discrete emotion" (p. 672). Given the fleeting nature of emotions, long completion time can lower the validity of the measure while also making it less practical in everyday use. By contrast, the IMDES features concise instructions and a relatively brief testing period; rating 24 abstract images at up to 5 s per image takes no more than 2 min.

Our findings advance beyond prior research on implicit emotion assessment in other important ways. First, we tested the IMDES by using diverse emotion manipulations: fear-evoking images, a sadness-inducing audio-recorded story (current studies), and an anger-provoking social encounter (Study 2 of Bartoszek & Cervone, 2017). By contrast, research examining the validity of other implicit emotion measures (Bode, 2014; Lee et al., 2020; Rohr et al., 2015) has relied primarily on one emotion-induction procedure, namely, the presentation of pictorial stimuli. This inherently leaves open the possibility that nonemotional artifacts of the specific induction method contributed to past results. Second, to provide robust evidence of the validity of the IMDES, we related implicitly assessed emotions to a diverse range of indices of affective responding: self-report, behavioral, and psychophysiological. Although prior research shows that the presentation of pictorial stimuli influenced evaluations of artificial words, neutral faces, or Chinese ideographs, it is difficult to confirm that such evaluations are emotion-driven without psychophysiological or behavioral measures. Last, our findings showed that fast responding on an implicit measure of emotions is key to the validity of such a measure. The response time manipulations, which to our knowledge have not been employed in any prior research on implicit emotion assessment, yielded unique evidence of the mechanisms underlying responses on the IMDES. In combination with psychophysiological and behavioral data, these manipulations indicate that fast (but not slow) responses are influenced by respondents' emotional states.

Mechanisms Underlying the Responses on the IMDES and the Implicitness of the Measure

To argue that a measure captures a specific construct, one needs to (1) demonstrate that the construct causes variations in responses on the measure and, ideally, (2) examine the processes through which the construct affects these variations (De Houwer, Teige-Mocigemba, Spruyt, & Moors, 2009). Moreover, to show that a measure is implicit, research should (3) provide evidence that the measure indexes the construct automatically (De Houwer et al., 2009). We believe that our data address all three tasks.

First, we believe that changes in the construct of interest—participants' emotional states—influenced the responses on the implicit measure: the ratings of abstract images. Psychophysiological, behavioral, and/or self-report data confirmed that our manipulation procedures were successful in producing emotional changes as expected based on participants' group membership. Subsequently, the groups differed in ratings of abstract images as a function of the emotion induction. Moreover, the correlations of these ratings with emotion-based psychophysiological and behavioral responses also support the idea that emotional states influenced the ratings. Although correlational data do not allow for claims about causality, it is unlikely that participants' ratings of abstract images affected the multiple facets of their emotional responding (e.g., physiological, behavioral). It is also difficult to conceive of a third variable, other than emotion, which would simultaneously affect the ratings and other emotion-based responses.

Second, our results strongly suggest that participants' misattributions of emotional states to the abstract images were driven by the intuitive and fast Type I processes (Evers et al., 2014). That is, participants likely relied on a heuristic approach using their feelings as information when making the evaluations (Forgas, 2001; Schwarz, 2011). Another possibility would be that nonemotional processes such as "cold" cognitive priming (e.g., Blaison et al., 2012) or demand characteristics (e.g., Nichols & Maner, 2008) produced the effects on the IMDES. However, if this were the case, one would not expect participants' evaluations of the abstract images to correlate with noncognitive indices of emotions: psychophysiological arousal and avoidance behavior. Similarly, these alternatives could not explain why the effects were diminished among slow-responding participants (Studies 1 and 3). In contrast, the dual-process framework does explain these differential effects. Because Type II processes are deliberate and analytical (rather than being primarily emotion-based), reliance on these processes in evaluations would decrease the robustness of the implicit measure while increasing the response times (Evers et al., 2014). Therefore, the fact that we observed a different pattern of results for fast and slow responding participants supports the notion that when participants rate the abstract images quickly, they rely on the heuristic, emotion-based Type I processes.

Third, the process through which the IMDES indexes the emotional states appears to possess several features of automaticity (Moors & De Houwer, 2006). Given that the responses to the implicit measure reflect participants' emotions, especially when the responses are provided quickly, the process is relatively fast. The misattributions of emotions to the ambiguous images also seem to be unintentional for two reasons. First, participants are not directed to use their feelings when rating the images but instead are asked a nonself-referential question (i.e., "What emotion did the artist try to express in this painting?"). Second, in Study 3, only 3% of participants evidenced an awareness of the effects of the emotion-manipulation procedure on their responses to the IMDES; after excluding their data, the pattern of results remained unchanged. Moreover, in Studies 1 and 2, participants were instructed to disregard the emotion-eliciting stimuli (i.e., the spider images) when rating the abstract images. Despite this instruction, participants' fast ratings were still influenced by the fear-provoking stimuli, and thus the process appears to be, to some extent, uncontrollable.

These automatic responses are in contrast to the reflective nature of responses on self-report measures, which more strongly engage the deliberate, Type II processes. One implication is that, as found in Studies 1 and 2, implicitly assessed emotions predict unique variance of emotion-related constructs (e.g., avoidance behavior, psychophysiology) unexplained by self-reported emotions. Furthermore, because the IMDES does not seem to require conscious consideration of one's emotions, it might be better in capturing emotional states in people with impaired access to such states (e.g., alexithymia, defensive repression; e.g., Kring et al., 2014; Lane et al., 2015). Future studies should test this possibility.

Limitations and Future Directions

The studies presented here are not without limitations. To improve the validity of the IMDES, we modified our assessment method across the studies by imposing time pressure, creating and pretesting new abstract images, and adding the feedback message to practice trials. Given the modifications, a question might remain as to the optimal format of the IMDES. We believe that the studies presented here answer this question. First, the measure would possess features that were common across the three studies: (1) concise instructions followed by (2) a series of items, each containing an abstract image, (3) a forced-choice scale with emotion labels, and (4) a nonself-referential question. The most important feature and the major object of our investigations would be (5) the time limit for responding. The version of the implicit measure presented in Study 2 is closest to this format. However, Study 3 data suggest that the measure requires no more than four practice trials (as compared with five in Study 2). Moreover, lack of responses to the practice items should be followed with (6) corrective feedback (e.g., "try to respond faster" message), as it was shown to reduce missing data.

Future studies should further test the abovementioned format of the IMDES in several ways. For example, we tested the criterion and incremental validity as related to fear, but similar studies could be conducted regarding emotions of anger and sadness. Additionally, each study validated the IMDES using a single-emotion manipulation, and future research should involve manipulation of multiple emotions in a single study. Nonetheless, the convergent and discriminant validity reported here indicates that the IMDES is capable of not only assessing but also differentiating emotions of the same valence. Moreover, implicit measures are developed because of their capability to overcome the limitations of self-report equivalents. This capability should be tested more closely, especially in populations who have difficulties identifying, understanding, and/or expressing their own emotions (e.g., alexithymia). The IMDES might prove particularly useful in clinical settings, as individuals with psychopathology might be particularly inaccurate in reporting their own emotions (Li, Zhang, Guo, & Zhang, 2015). Last, our results indicate that imposing time pressure increases one's reliance on emotions in responding. This has implications beyond the development of the specific measure presented here. Indeed, we believe that imposing time pressure in responding would enhance the validity of other implicit measures that rely on affective processes (Lee et al., 2020; Payne & Lundberg, 2014; Quirin et al., 2009).

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