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Reliability, validity and sensitivity of a computerized visual analog scale measuring state anxiety

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ABSTRACT

Background and objectives: Assessment of state anxiety is frequently required in clinical and research settings, but its measurement using standard multi-item inventories entails practical challenges. Such inventories are increasingly complemented by paper-and-pencil, single-item visual analog scales measuring state anxiety (VAS-A), which allow rapid assessment of current anxiety states. Computerized versions of VAS-A offer additional advantages, including facilitated and accurate data collection and analysis, and applicability to computer-based protocols. Here, we establish the psychometric properties of a computerized VAS-A.

Methods: Experiment 1 assessed the reliability, convergent validity, and discriminant validity of the computerized VAS-A in a non-selected sample. Experiment 2 assessed its sensitivity to increase in state anxiety following social stress induction, in participants with high levels of social anxiety.

Results: Experiment 1 demonstrated the computerized VAS-A's test-retest reliability ($r = .44$, $p < .001$); convergent validity with the State-Trait Anxiety Inventory's state subscale (STAI-State; $r = .60$, $p < .001$); and discriminant validity as indicated by significantly lower correlations between VAS-A and different psychological measures relative to the correlation between VAS-A and STAI-State. Experiment 2 demonstrated the VAS-A's sensitivity to changes in state anxiety via a significant pre- to during-stressor rise in VAS-A scores ($F(1,48) = 25.13$, $p < .001$).

Limitations: Set-order administration of measures, absence of clinically-anxious population, and gender-unbalanced samples.

Conclusions: The adequate psychometric characteristics, combined with simple and rapid administration, make the computerized VAS-A a valuable self-rating tool for state anxiety. It may prove particularly useful for clinical and research settings where multi-item inventories are less applicable, including computer-based treatment and assessment protocols. The VAS-A is freely available: http://people.socsci.tau.ac.il/mu/anxietytrauma/visual-analog-scale/.

Measuring state anxiety has always been a challenge for researchers and clinicians. The use of visual analog scales (VAS) in the measurement of transient and subjective psychological states is becoming increasingly popular (Bijur, Silver, & Gallagher, 2001; de Boer et al., 2004; Gift, 1989; McCormack, Horne, & Sheather, 1988; Rossi & Pourtois, 2012). These single-item measures (also referred to as subjective units of distress), in which participants mark their subjective status on a visual scale, afford simple and rapid administration, and increased comprehension and completion rates (Rossi & Pourtois, 2012). These properties are particularly advantageous for the assessment of state anxiety when the completion of gold-standard multi-item inventories of state anxiety, such as Spielberger's State-Trait Anxiety Inventory (STAI-State; Spielberger, Gorsuch, & Lushene, 1970), may be burdensome. Indeed, visual analog scales for the measurement of anxiety (VAS-A) usefully complement multi-item questionnaires in a variety of clinical settings requiring rapid and unobtrusive anxiety measurement, including psychotherapy sessions and anxiety assessment among patients that are severely-ill, or are before or in surgery (e.g., Chlan, 2004; Kellner, Wiedemann, Yassouridis, & Muhtz, 2012; Kindler, Harms, Amsler, Ihde-Scholl, & Scheidegger, 2000; Mouthaan, Sijbrandij, Reitsma, Gersons, & Olff, 2011). Similarly, experimental designs that require rapid and repeated anxiety assessments (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker,

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2002; Poma et al., 2005) may benefit from the use of the VAS-A instead of a multi-item inventory, as the latter may prove more disruptive to the experiment flow and possibly obscure the transient, situational essence of state anxiety. Different psychometric properties of various paper-and-pencil versions of VAS-A have been explored in a number of studies (reviewed in Rossi & Pourtois, 2012), collectively establishing adequate test-retest reliability, convergent and divergent validity, and sensitivity to stress-induced changes in state anxiety of these instruments (Bond, Shine, & Bruce, 1995; Cella & Perry, 1986; Chlan, 2004; Davey, Barratt, Butow, & Deeks, 2007; Hornblow & Kidson, 1976; Kindler et al., 2000; Luyk, Beck, & Weaver, 1988; Seddon et al., 2011).

Computer-based applications for medical and psychological data collection, including self-assessment and psychological inventories, are becoming increasingly available and frequently used (e.g., Allenby, Matthews, Beresford, & McLachlan, 2002; Broderick & Vikingstad, 2008; Burton, Weller, & Sharpe, 2009; Jamison et al., 2001; Schulenberg & Yutrzenka, 1999). These electronic measures may offer various advantages over paper measures, such as facilitation of data collection, handling, and analysis, and increased patient compliance and recording accuracy (Gwaltney, Shields, & Shiffman, 2008; Palermo, Valenzuela, & Stork, 2004; Ryan, Corry, Attewell, & Smithson, 2002; Stone, Shiffman, Schwartz, Broderick, & Hufford, 2003). They may also enable more seamless data collection when embedded in computerized experiments (Grafton, Mackintosh, Vujic, & MacLeod, 2013; Maoz, Abend, Fox, Pine, & Bar-Haim, 2013), or in situations where paper measures are not applicable, such as during magnetic resonance imaging (Lueken, Muehlhan, Evens, Wittchen, & Kirschbaum, 2012; Thorpe, Salkovskis, & Dittner, 2008). Importantly, as the dissemination of psychological assessment and treatment via computer-based means, including the Internet, is rapidly growing, the clinical applications of computerized state anxiety measurement are likewise increasing. For example, VAS assessment of anxiety can be embedded in computer- or Internet-based protocols of therapy interventions (Farrer et al., 2013; Grafton et al., 2013; Mouthaan et al., 2011). Likewise, the growing prevalence of smartphones and other mobile devices is being utilized for more ecological momentary assessment of clinical subjective states, including anxiety (Dockray et al., 2010; Reid et al., 2009; Schaffer, Kreindler, Reis, & Levitt, 2013; Shiffman, Stone, & Hufford, 2008). However, the use of the computerized medium should also be coupled with validation of the instruments used in it (Bishop et al., 2010; Coons et al., 2009; Hirsch, Hauschild, Schmidt, Baum, & Christiansen, 2013; Kongsved, Basnov, Holm-Christensen, & Hjollund, 2007). While it may be argued that paper and computerized VASs are graphically comparable and should therefore hold the same psychometric properties, it has been shown that ratings using the two formats may be similar but not necessarily completely equivalent (Junker et al., 2008; Kvien et al., 2005; Stratton et al., 1998; Stubbs et al., 2000; Whybrow, Stephen, & Stubbs, 2006), thus suggesting that the assessment of psychometric properties of such instruments is warranted. A number of studies validated computerized VASs for the measurement of different subjective states, such as chronic pain, hunger, and quality of life (Hollen et al., 2013; Jamison et al., 2002; Kvien et al., 2005; Salaffi, Gasparini, & Grassi, 2009; Stubbs et al., 2000; Whybrow et al., 2006). To the best of our knowledge, the psychometric properties of a computerized VAS for the assessment of state anxiety have yet to be comprehensively studied.

Here, we evaluated the reliability, validity, and sensitivity of a computerized single-item VAS-A in measuring state anxiety. In Experiment 1, we assessed the VAS-A's: a) reliability, using test–retest measures; b) convergent validity, by testing whether VAS-A scores significantly correlated with STAI-State scores (Spielberger, 1983); and c) discriminant validity, by comparing the magnitude of correlation between the VAS-A and the STAI-State to the correlations between the VAS-A and other negative affect instruments not assumed to directly measure state anxiety, such as trait anxiety, social anxiety, depression, and state anger. In Experiment 2, we examined whether the VAS-A was sensitive to changes in state anxiety following stress-induction in a sample of socially-anxious individuals participating in a public speaking task.

1. Experiment 1: reliability, convergent validity, and discriminant validity of the VAS-A

In Experiment 1, we tested the reliability, convergent validity, and discriminant validity of the computerized VAS-A in measuring state anxiety.

1.1. Method

1.1.1. Participants

We recruited 172 undergraduate students (mean age 23.8 years, SD = 2.8; 125 females) from Tel Aviv University ($n = 99$) and the Yezreel Valley College ($n = 73$). The study was approved by the local institutional review boards. Participants provided signed informed consent, and received course credit or monetary compensation for their participation.

1.1.2. Measures

1.1.2.1. Computerized VAS-A. The VAS-A was administered on a standard 15.6" laptop screen using a Java applet (Fig. 1). Consistent with common VAS presentations, the scale was a 100-mm horizontal line (Ahearn, 1997; Wewers & Lowe, 1990) divided into 30 equal-sized partitions (MacLeod et al., 2002). The left edge of the scale was marked "calm" and the right edge was marked "anxious" (for relevant uses, see Buhr & Dugas, 2009; MacLeod et al., 2002; Watson & Tellegen, 1985). A sliding locator was initially positioned at the midpoint of the scale. The scale was presented within a gray window 128 mm wide and 96 mm tall. The experimenter instructed the participants to use the computer mouse to place the locator at the scale position representing their current level of anxiety ("How anxious do you feel right now?"). Score was automatically calculated by rounding the relative distance of the locator from the left edge of the scale to the nearest integer value between 0 and 30. The participants were not informed of this numerical value. The VAS-A is freely available for download at http://people.socsci.tau.ac.il/mu/anxietytrauma/visual-analog-scale/.

1.1.2.2. State-Trait Anxiety Inventory – state subscale (STAI-State). The STAI-State (Spielberger et al., 1970) consists of 20 items relating to present anxious moods answered on a 4-point scale from 1 = *Not at all* to 4 = *Very much so*. Item scores are summed to a total score (range: 20–80). The STAI-State scale has high internal consistency, with Cronbach's alpha coefficient ranging between .86 and .95 and item–remainder correlations of .55–.63 (Rossi & Pourtois, 2012; Spielberger, 1983; Spielberger & Sydeman, 1994). Its stability coefficients are relatively low (test–retest $r = .34$–.62 in various

Fig. 1. The computerized VAS-A. Participants were instructed to use the computer mouse to place the locator at the scale position representing their current level of anxiety in response to the question, "How anxious do you feel right now?"