A Modified Computer Version of the Paced Auditory Serial Addition Task (PASAT) as a Laboratory-Based Stressor

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To simulate psychological stress in laboratory studies of psychopathology, researchers have used a variety of stressful tasks that have included exposure to challenging problems (e.g., mental arithmetic, puzzles; Pike, Smith, Hauger, & Nicassio, 1997; Sharpley & Gordon, 1999; Sharpley, Power, Mollard, & Parsons, 1993), time pressure (e.g., reaction time; Light & Sherwood, 1989; Schneider, Julius, & Karunas, 1989; Sharpley & Gordon), physical exercise (e.g., deep knee bends, hand grip; Emmons, Weidner, & Collins, 1989; Schneider et al., 1989), aversive stimuli (e.g., cold pressor task, electric shock, upsetting video footage, loud auditory noise; Ader & Tatam, 1961, 1963; Allen & Crowell, 1989; Butler, Wells, & Dewick, 1995; Lejuez, O'Donnell, Wirth, Zvolensky, & Eifert, 1998; Van Gemmert & Van Galen, 1997; Weisse et al., 1990), and/or social performance demands (e.g., presentation of a speech, social interaction with strangers; Breslin & Wilson, 1992; Stoney & Hughes, 1999). Within this large body of research using stressors, however, a lack of consistency in the procedural details of these studies necessarily limits across-study comparisons. Further, whereas most tasks have particular strengths, few allow for the flexibility to comprehensively examine responses across behavioral/motor, cognitive/self-report, and physiological response modes in an experimentally precise manner. To address this need, we present a modified version of the Paced Auditory Serial Addition Task (PASAT), referred to here as the PASAT-C.

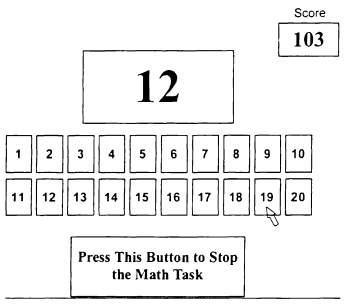

Fig. 1. The screen presentation for the computerized version of the Paced Auditory Serial Addition Task (PASAT).

PASAT

The PASAT, originally developed for the assessment of information processing and capacity in patients with head trauma (Gronwall, 1977), is widely used as a neuropsychological test that indexes sustained attention (Cohen, 1993), divided attention (van Zomeran & Brouwer, 1994), information processing (Gronwall; Gronwall & Wrightson, 1981), and mental tracking (Lezak, 1995). The task involves the participant adding a verbally presented digit to the previous verbally presented digit. After verbally answering with the sum, the participant must then ignore that sum and add the following digit to the previous digit. For example, the correct answers to the series of 7, 8, 4, 5, 1 would be 15, 12, 9, and 6.

Despite evidence for the utility of the PASAT as a neuropsychological assessment device (Deary, Langan, Hepburn, & Frier, 1991; Gronwall & Wrightson, 1981), the task also has been criticized for these purposes because it produces elevated levels of stress (Deary et al., 1994; Holdwick & Wingenfeld, 1999; Lezak, 1995; Roman, Edwall, Buchanan, & Patton, 1991). Although the production of stress may be undesirable when the primary goal is the assessment of neuropsychological functioning, this feature also suggests the potential utility of the task as a laboratory inducer of psychological stress. Given these findings, we developed the PASAT-C to serve as a laboratory inducer of psychological stress. In this context, we have utilized particular modifications to exacerbate reactions (e.g., unpleasant auditory feedback for incorrect answers) and to increase precision and control (e.g., computerized execution of exact latencies between number presentation, as well as computerized determination of participant response accuracy and latency). Although these modifications likely limit any reliable neuropsychological assessment, we present this modified version of the PASAT as an experimentally rigorous measure capable of precise assessment of behavior across behavioral/motor, cognitive/self-report, and physiological response modes.

Description of the Modified Task

The PASAT-C (see Figure 1) is a modified computer version of the standard PASAT used to assess neuropsychological functioning. The version described below is that used most frequently in our laboratory, yet most of the parameters can be modified (e.g., number of levels, latency of stimulus presentation) to better suit particular experimental needs. The basics of the task are taken from the standard PASAT, with a few exceptions. First, whereas stimuli in the standard version are presented orally, the stimuli on the modified task are presented in a 70-point bold font within a 7.62 cm (w) × 3.81 cm (h) rectangle on the upper middle area of the computer screen. Also, unlike the standard version in which participant responses are provided orally, the modified version requires answers to be provided via a computer mouse click on a keypad (including the numbers 1 through 20) pictured in the lower middle area of the computer screen. The numbers are presented in an 18-point bold font within a 1.25 cm (w) × 1.9 cm (h) box (1 through 10 on the top row and 11 through 20 on the bottom row). Each box is separated by .5 cm. Finally, the participant's score, presented in 32-point bold font, is continuously updated within a 3.2 cm (w) × 1.9 cm (h) box.

The version of the PASAT-C described here consists of three levels. As shown in Table 1, Level 1 provides a 3-s latency between number presentations (i.e., low difficulty). Level 2 provides a 1.5-s latency between number presentations (i.e., medium difficulty). Level 3 provides a 1-s latency between number presentations (i.e., high difficulty). Level 1 continues for 3 min and then transitions without warning to Level 2, which lasts for 5 min. The seamless transition is especially useful if the experimenters are interested in sensitivity to subtle experimental manipulations. A 2-min break separates Level 2 and 3, during which self-report ratings and other desired assessment data may be collected.

Immediately prior to the start of Level 3, a 15-s warning period is used to alert the participant that the session will soon resume. Specifically, the screen displays the message "get ready" for the first 5 s, "get set" for the second 5 s, and "go" for the final 5 s. Following the warning period, Level 3 lasts up to 10 min, with the participant given an explicit "escape" option. Participants are informed about

this escape option prior to the start of the task. Specifically, they are told that at some point in the experiment, a box labeled QUIT will appear below their answer keypad and that clicking the mouse anywhere on this box will terminate exposure to the task. The dimensions of the box are 9.5 cm (w) × 3.2 cm (h). To provide incentive to complete the task to the best of their abilities, participants also are told that they will receive a gift certificate if their total number of points earned is greater than the average score of the other participants. It is further explained that this "target" score cannot be determined until the end of participation, but in the event that the participant's score exceeds the target score, the gift certificate will be sent in the mail about 4 weeks after participation. We used a small amount (i.e., $5) to produce some incentive for continuing the task without creating a ceiling effect in the duration of endurance across participants.

Data Supporting the Utility of the Task

To be an effective psychological stressor, it is necessary that the task be shown to produce effects across motor/behavioral, cognitive/self-report, and physiological response channels (Lang, 1971). In pilot data from our laboratory we exposed 32 individuals to the PASAT-C. Of the participants, 87% were Caucasian, 50% were male. These participants averaged 13.3 years of education (SD = 2.0) and the mean age was 44.3 years (SD = 9.6).

Cognitive/self-report. The use of self-report measures built into the PASAT-C allows for the on-line assessment of subjective effects produced by the task. Although any combination of variables can be examined, we have focused on the assessment of variables thought to be indicative of psychological stress (i.e., anxiety, difficulty concentrating, and irritability). As a validity check, we also measured the effects of the task upon self-reported bodily discomfort, a variable unlikely to be affected by the task. Self-report assessments were taken at baseline and again following the completion of Level 2. Level 2 was chosen over Level 1 and Level 3 because we were concerned about the limited degree of difficulty in Level 1 and the differences in duration across participants in Level 3 due to the termination option.

Self-report of anxiety, difficulty concentrating, bodily discomfort, and irritability were completed on the computer via a 0 (*none*) to 100 (*extreme*) visual analog scale with a mouse-manipulated marker. Using repeated-measures Analyses of Variance (ANOVAs) to compare reports at baseline and at the end of Level 2, anxiety, $F(1, 31) = 10.51, p = .003$, difficulty concentrating, $F(1, 31) = 26.5, p < .001$, and irritability, $F(1, 31) = 18.82, p < .001$, all increased significantly. Additionally, self-report of bodily discomfort, a measure unlikely to be affected by the PASAT-C, did not significantly increase from the baseline to the experimental period, $F(1, 31) = 2.52, p > .10$.

Physiological arousal. The design of the PASAT-C allows for the assessment of overall physiological responding. Additionally, the use of transition and rest periods allows for more precise analyses of habituation within each level (i.e., a systematic decrease in arousal as the novelty of the task decreases) and potentiation across levels (i.e., a spike in arousal during the transition from one level to the next), as well as anticipatory effects during the clearly defined warning period that signals the impending start of Level 3. Further, the additional baseline measurement provided during the rest period between Level 2 and Level 3 allows for more accurate change scores for Level 3 responses than that available using the preexperimental baseline assessment.

To address physiological responding we used a Biopac MP 100 system to digitally record skin conductance level (SCL) and heart rate (HR) data on-line at a sample rate of 10 samples/s across all channels using Biopac's Acqknowledge Software. SCL (in microsiemens) was obtained using the Biopac GSR100B electrodermal activity amplifier with the TSD103A Ag-AgCl electrodes placed on the middle segment of the middle and ring fingers. Raw electrocardiogram data were collected using the Biopac ECG100B Electrocardiogram amplifier, with disposable Ag/AgCl electrodes aligned in a standard configuration (right and left of sternum just below the clavicle). These raw data were converted to obtain HR in beats per min.

The PASAT-C effectively increased participants' physiological arousal, with the most robust effects evidence in SCL (see Figure 2). Compared to baseline values, SCL increased during the first 10 s of Level 1, $F(1, 31) = 16.1, p = .0004$, Level 2, $F(1, 31) = 20.6, p < .0001$, and Level 3, $F(1, 31) = 32.7, p < .0001$. Further, these effects remained throughout both Levels 1 and 2, and actually a slight increase in SCL was evidenced by the last 10 s of each these levels. Finally, anticipatory effects also were evident. Specifically, SCL significantly increased from the baseline period compared to the 15-s warning period immediately prior to Level 3, $F(1, 31) = 31.6, p < .0001$.

Regarding HR, the pattern of data was somewhat consistent with that found for SCL, yet considerably less robust.[1] Specifically, a significant increase from baseline levels was found at the first 10 s of Level 1, $F(1, 31) = 10.0, p = .004$, but not at Level 2 or 3. Additionally, anticipatory effects were found; HR significantly increased from the baseline period compared to the 15-s warning period immediately prior to Level 3, $F(1, 31) = 4.32, p = .047$.

Motor/behavioral. On a motor/behavioral level, there are several useful dependent measures to assess both performance and persistence on the PASAT-C. We examined task performance as a function of number of correct responses. As expected, performance decreased as the number presentation latency decreased. During Level 1, scores ranged from 1 to 57 (M = 21.4; SD = 12.14) out of a possible 59 (36% correct). Performance dropped considerably in Level 2 with scores ranging from 0 to 103 (M = 21.93; SD = 21.4) out of a possible 199 (11% correct). Level 3 scores ranged from 0 to 87 (M = 19.56; SD = 22.79). The variation in termination durations limited the utility of comparing these scores to an absolute total score for the entire 600 s, but adjusting the total score based upon the average termination latency resulted in an average maximum score of 332 (6% correct).

Several factors should be considered when interpreting exactly what is being measured by performance. Based upon data from the standard version of the PASAT and the simplicity of the computations, it is unlikely that intelligence or mathematical ability were affecting score on the PASAT-C (Deary et al., 1991). In contrast, attention and reaction time are factors that may be especially relevant because of the established attentional component of the standard PASAT (Deary

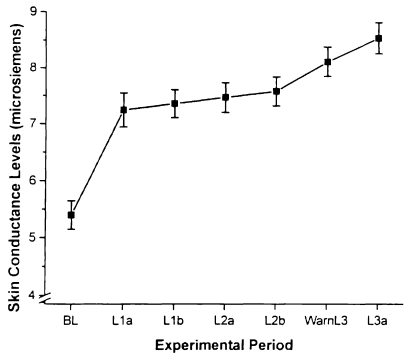

Fig. 2. The pattern of Skin Conductance Level (in microsemens) changes across various experimental periods of the computerized version of the Paced Auditory Serial Addition Task (PASAT). X-axis labels are abbreviated as follows. BL = preexperimental baseline; L1a = first 10 s of Level 1; L1b = last 10 s of Level 1; L2a = first 10 s of Level 2; L2b = last 10 s of Level 2; WarnL3 = the 15 s warning period prior to Level 3; L3a = first 10 s of Level 3. The vertical bar through each symbol represents standard error of the mean.

[1] The less robust HR findings are not surprising given that many researchers have questioned the use of HR changes as an index of anxiety and psychological stress (Fowles, 1983).

et al.; Gronwall & Wrightson, 1981). To reduce the effect of any mouse skill-related effects, a touch screen could be used instead of a mouse. However, it should be acknowledged that the psychological stress produced by the task might be reduced in the absence of the extra motor requirement of the mouse, even if number presentation latencies are reduced to accommodate the less complex response. This caution is especially true when utilizing a slower mouse speed, which often serves the effect of preventing participants from answering quickly enough to get credit despite their clear knowledge of the correct answer.

In addition to performance, the PASAT-C allows for the assessment of persistence/frustration tolerance, indexed by latency to terminate the PASAT. In our sample, we found a wide distribution of termination latencies. Specifically, the average termination time was 354.9 (SD = 245.8) out of a possible 600 s, with 8 (25%) participants terminating the task in the first 100 s and 12 (37.5%) participants completing the entire 600 s. Because within most samples a subset of the participants complete the entire 600 s, the distribution of scores is unlikely to be normal and thereby requires a statistical transformation or the use of statistics for which normalcy is not a requirement. Alternatively, participants could be grouped by the presence or absence of a termination response as opposed to the duration of termination latency, with the resulting data analyzed using a chi-square analysis. As a fourth option, we chose to analyze our data using continuous time survival analysis as implemented in SAS using PROC PHREG. This method allows for analysis of participants who never experience an index event (in this case-task termination) during a given period of time.

Results of survival analyses indicated that age, education, gender, and a self-reported index of familiarity with a computer mouse were not related to termination latency, $ps < .30$. However, performance on the PASAT, as indexed by score on the first two levels, did predict termination latency, with higher scores being associated with lower relative risk of task termination across the 10-min trial (Relative Risk [RR] = .95, $p < .018$). This relation raises the possibility that participants' proficiency at the task (potentially including attention level and motor speed), and not other factors related to persistence, may have determined termination latency.

Although the potential confound of performance and persistence appears problematic, features of the current data suggest that these variables may be acting at least somewhat independently. Indeed, it should also be noted that despite the association between performance and termination latency, neither self-report ratings at baseline nor following Level 2 were correlated with performance, whereas relations between these reports and termination latencies were found. Specifically, controlling for performance, higher self-reported irritability at baseline (RR = 1.03; $p = .021$) and after Level 2 (RR = 1.02; $p = .011$) was associated with relatively greater risk of task termination during Level 3. Also, difficulty concentrating after Level 2 was associated with greater risk of task termination (RR = 1.02; $p < .018$). Difficulty concentrating at baseline as well as anxiety and bodily discomfort at both baseline and Level 2 were not significantly associated with survival to task termination, $ps > .05$. These results suggest that cognitive and affective processes, unrelated to performance, may influence termination latencies. In particular, the relation between termination latencies, as well as both baseline and within-session levels of irritability, suggests that a construct such as frustration tolerance may be of interest.

Nevertheless, the link between performance and persistence makes intuitive sense and always should be considered when interpreting data using this task. Along these lines, one advantage of the current task compared with other similar tasks in which performance is not assessed is that the effect of performance on termination latencies can be addressed statistically. That is, when using the PASAT-C to assess between-group differences, score can be used as a covariate to determine if group differences in termination latency exist independent of performance.

Conclusions

In conclusion, we present the PASAT-C as a tool that may be used to produce psychological stress in laboratory examinations of experimental psychopathology. Most importantly, this task allows for the comprehensive examination of behavioral/motor, cognitive/self-report, and physiological response modes without sacrificing experimental precision and control. Further, the procedural details can be easily manipulated to best suit the particular research question.

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TABLE 1. Procedural Details for the PASAT-C

Level	Duration	Presentation Latency	Possible Correct	Preceded by	Followed by
Level 1	3 min	3.0 s	59	10-min baseline	Seamless transition to Level 2
Level 2	5 min	1.5 s	199	Seamless transition from Level 1	2-min assessment period 15-s warning period
Level 3	10 min	1.0 s	599	2-min assessment period 15 s warning period	End of task

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Lighter Side

So You Call Yourself a Doctor?

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You've heard it a thousand times: Kids say the darnedest things. I guess it's that sweet innocence that relinquishes them from the constraints that hold most of us back from saying what we really think.

I recall many years ago, my wife and I were hosting a dinner party at our home when one of our guests, a colleague of mine, asked my son Michael, then age 7, "So, what do you want to be when you grow up?" Michael replied sheepishly, "Eh, a doctor, I guess." "Oh, like your dad?" my colleague offered. "Nah," my son said, "I want to be a real doctor." Needless to say, everyone in the room roared with laughter. Needless to say, little Mikey saw an early bedtime that evening. Well, lucky for him he had no trouble falling asleep, because I certainly tossed and turned that night. I don't know what it was that irked me most about my son's comment, but maybe it was that "out of the mouths of babes" thing, and this was out of "my babe." I was never one to take my education lightly; but, on the other hand, I never corrected anyone who referred to me as Mister, even in such formal circumstances as a lecture or in court. I always preferred a first-name basis with both my students and my patients, and I certainly avoided making any comments that might be construed as condescending. But my son's statement ate at me, probably because it wasn't the first time I had heard it. So I got to thinking about what actually constitutes a doctor, why some doctors are doctors according to most everyone, no question; and why others are, well, a matter of opinion.

Many believe that "doctor" should be reserved exclusively for the physician, the one and true healer. Yet, there are many double messages as far as usage. Some nonphysician professionals are referred to as "doctor" in certain contexts, but not in others. For example, during a deposition or when testifying in a court of law, the judge, attorneys, tip staff, and even the shoeshine man in the courthouse address me respectively as Doctor, yet the newspapers tell me that they only use the title when the individual is a physician. That is, of course, unless you die. The dead person with a doctoral degree is a "Doctor