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Type D personality and cardiovascular reactivity to an ecologically valid multitasking stressor

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Abstract

Previous research investigating the influence of Type D personality on cardiovascular reactivity to stress in healthy young adults is somewhat mixed. The present study sought to investigate this question using an ecologically valid laboratory stressor. Beat-to-beat blood pressure and heart rate were measured in 77 healthy young adults during exposure to multitasking stress. Mood and background stress were both associated with Type D personality when Type D was conceptualised as a dimensional construct, with less robust findings observed using the traditional dichotomous typological approach. However, the continuous Type D construct added limited predictive value of the self-report measures above that of its constituent components, negative affectivity (NA) and social inhibition (SI). Further, an inverse relationship between the continuous Type D construct and blood pressure reactivity to multitasking stress was observed. In summary, our findings suggest that Type D personality is predictive of blunted cardiovascular reactivity to stress in healthy individuals when Type D is considered as a dimensional construct and the independent influence of NA and SI is controlled for. Further, our findings suggest that Type D does not predict additional variance in mood and background stress above that of NA and SI when these constituent factors are considered independently.

Keywords: Type D, personality, heart rate, blood pressure, stress, mood

Word count: 9,200

Introduction

Type D (distressed) personality is characterised by high levels of both negative affectivity (NA) and social inhibition (SI). Previous research has observed that Type D personality is associated with adverse health outcomes in coronary heart disease, characterised by recurrent coronary events. For example, Type D status has been associated with mortality (Denollet et al., 1996), recurrent myocardial infarction (Denollet et al., 2000), treatment non-adherence (Williams et al., 2011) and depression (Denollet & Brutsaert, 1998) in coronary patients.

Heightened cardiovascular reactivity to stress, hyper-reactivity of the hypothalamic-pituitary-adrenal (HPA) axis (including an elevated cortisol awakening response; Whitehead et al., 2007), and the subsequent release of stress hormones have all been postulated as mechanisms by which Type D individuals are at risk for adverse clinical outcomes following coronary events (Pedersen & Denollet, 2006). To appropriately address this hypothesis, prospective research is needed to investigate whether a relationship exists between Type D personality and stress reactivity pre-clinically, and in turn, whether those Type D individuals who demonstrate greater psychobiological reactivity to stress develop clinically relevant coronary abnormalities. Anecdotally, prolonged lifetime exposure to cardiovascular stress and overexposure to stress hormones such as cortisol, adrenaline and noradrenaline could place such individuals at risk of chronic cardiovascular health complications in later life. Several studies have now taken the first step in testing the hypothesis that psychobiological hyper-reactivity to stress could be a mechanism by which Type D individuals are more susceptible to adverse health comes following coronary events. However the findings are somewhat mixed. Two previous studies found no influence of Type D on blood pressure reactivity to mental arithmetic tasks (Howard & Hughes, 2013; Williams et al., 2009), although one of these studies found a significant effect of Type D on cardiac output

(Williams et al., 2009) and the other observed sensitised blood pressure reactivity to the second administration of a mental arithmetic stressor in Type D males (Howard & Hughes, 2013). A further study observed that males high in SI showed greater blood pressure reactivity to arithmetic, while heart rate reactivity was blunted in males high in NA (Habra et al., 2003). In line with Habra's (2003) finding of blunted heart rate reactivity, one recent study has reported blunted cardiovascular reactivity to psychosocially evaluated mental arithmetic in well-rested Type D individuals (O'Leary et al., 2013). It has recently been suggested that a blunted cardiovascular response to stress is predictive of adverse cardiovascular health outcomes via four possible mechanisms: i) reduced motivation or effort, ii) reduced awareness or perception of stress, iii) the administered stressor being too challenging (resulting in task disengagement), or iv) physiological inability to mount an adequate physiological response to stress (Phillips et al., 2013). According to this cardiovascular blunting account, Type D personality could influence cardiovascular health via blunted cardiovascular reactivity to stress, mediated by either of these mechanisms.

The laboratory stressors which have been employed in these previous investigations have tended to comprise cognitive tasks such as demanding mental arithmetic. However, an important consideration of studies designed to induce stress in the laboratory is that the administered stressors should be representative of the demands that an individual may routinely face in the real world (Kudielka & Wust, 2010; Wetherell & Carter, in press). This is a particularly important consideration in context of the premise that the increased risk of adverse coronary health outcomes in Type D individuals arises from recurrent lifetime atypical reactivity to stress. In order to adequately address this question, studies need to ensure that the laboratory stressor employed is analogous to the kinds of stress which participants are routinely exposed to on a day to day basis. An example of one such ecologically valid stressor is that of multitasking (Wetherell & Carter, in press). Similarly to the stressors employed by previous Type D studies in young adults, the Multitasking Framework (Wetherell & Sidgreaves, 2005) is performance-based and cognitively demanding, but has the advantage of being representative of environments where participants have to attend and respond to several different stimuli simultaneously, such as in many busy work settings. It is therefore of interest to investigate the influence of Type D on cardiovascular reactivity to an ecologically valid, multitasking stressor.

Despite the reportedly higher prevalence of Type D among coronary and hypertensive patients than healthy controls (Denollet, 2005), there is limited evidence that Type D personality is a predictor of primary coronary heart disease risk (i.e. risk of first coronary event in individuals without clinically established coronary disease; Larson et al., 2013). Indeed, on the basis of some studies which have failed to replicate the evidence for Type D as a predictor of coronary health outcomes, some authors have questioned the predictive value of the Type D construct (Coyne et al., 2011; Grande et al., 2011). More recently, it has been argued that research investigating Type D personality as a predictor of cardiovascular disease endpoints should be abandoned altogether (de Voogd et al., 2012). For example, the strong positive relationship between NA and neuroticism, and the strong inverted relationship between SI and extraversion (De Fruyt & Denollet, 2002; Howard & Hughes, 2012) brings into question whether Type D personality is merely a re-conceptualisation of established personality traits. However, there is evidence for the discriminant validity of SI and extraversion, particularly with respect to the prediction of cardiovascular function (Howard & Hughes, 2012). One of the main criticisms of Type D research is that Type D has previously been conceptualised using a dichotomous typology, whereby individuals with high scores on both NA and SI are categorised as ‘Type D’, with other participants being characterised as ‘non-Type D’ (Coyne et al., 2011; Ferguson et al., 2009). However, more recent studies have also investigated the influence of a dimensional Type D construct on various outcome measures, with the continuous predictor variable being the interaction of NA and SI scores (e.g. Coyne et al., 2011; Williams et al., 2012). It has been argued (Borkoles et al., 2012; Coyne et al., 2011) that this approach is the most appropriate method statistically, avoiding the use of arbitrary cut-offs to denote caseness. Further, Denollet's suggestion that Type D should be conceptualised as the moderation by SI of the influence of NA on clinical outcomes (Denollet et al., 1996) provides support for the dimensional approach in favour of the traditional typological approach (Williams et al., 2012). A further benefit of the dimensional approach is that a continuous Type D variable can be considered as a predictor variable in a hierarchical regression analysis, which permits the additive predictive value of Type D over its constituent components (NA and SI) to be ascertained. This is a question which will be addressed in the present study. Finally, an additional criticism of Type D research is that the majority of studies investigating the influence of Type D on adverse clinical coronary outcomes have been conducted by a single group (Coyne et al., 2011; Smith, 2011). A recent meta-analysis which found support for a relationship between Type D personality and health status in coronary patients (Versteeg et al., 2012) was over-represented by studies from Denollet's group, whom also conducted the meta-analysis itself (Coyne & de Voogd, 2012). However, this same criticism cannot be levelled at the body of research which has investigated the relationship between Type D and physiological functioning in healthy individuals, which has been conducted by several different research groups.

Here, we aimed to investigate the influence of Type D personality on cardiovascular reactivity to ecologically valid multitasking stress. We also incorporated self-report measures of mood, perceived workload and background stress. Using the approach taken by several recent investigations in this area, we sought to investigate the influence of Type D personality on our outcome measures using both a typological and a dimensional approach. Further, we conducted hierarchical regression analyses to investigate NA and SI as independent predictors of the outcomes under consideration, in addition to the unique predictive value of the interaction of NA and SI, controlling for any variance shared with the two constituent factors of Type D when they are considered independently. Predicated by previous work which has observed blunted cardiovascular reactivity to in healthy young adults (Howard et al., 2011; O'Leary et al., 2013), it was hypothesised that Type D personality would be associated with a blunted cardiovascular reactivity to the multitasking stressor, in addition to elevated background stress and decreased mood.

Method

Participants

A total of 77 healthy young adults aged 19-29 years took part in the present study (31 males, $M_{\text{age}} = 21.0$, $SD_{\text{age}} = 1.6$). Some of the participants were undergraduate psychology students recruited from Northumbria University who participated in exchange for partial course credit. Others were recruited via a sample of convenience and were reimbursed with £5 high street vouchers.

Materials

Multitasking Framework. The Multitasking Framework (Purple Research Solutions, UK; see Wetherell & Sidgreaves, 2005) required participants to simultaneously perform four tasks which were presented on a computer screen and is representative of everyday situations that require individuals to attend and respond to several stimuli concurrently (Wetherell & Carter, in press). The four Framework modules used in this study were Memory Search, Mail Alert, Target Tracker and Telephone Number Entry (see Figure 1 for a screen grab depicting the four modules as presented in the present study). All modules were set to ‘medium’ intensity, with the exception of ‘Letter Search’ which was set to ‘high’ intensity. This framework configuration was designed to induce high levels of stress, without making the task so difficult that participants disengage from it.

INSERT FIGURE 1 ABOUT HERE

Type-D scale-16 (DS16). The DS16 (Denollet, 1998) was developed to measure Type D personality. The 16 item questionnaire comprised two eight item subscales: Negative Affectivity (NA; e.g. 'I take a gloomy view of things') and Social Inhibition (SI; e.g. 'I find it hard to make "small talk"'). Reponses to each item were made on a 5-point scale ranging between 0 and 5, yielding a total score of between 0 and 32 for each subscale. Both subscales have been found do demonstrate good internal consistency (NA: α = 0.89, SI: α = 0.82; Denollet, 1998).

Perceived Stress Scale (PSS). The PSS-10 (Cohen et al., 1983) is a ten item questionnaire which was used in the present study as a measure of background stress. The single-factor scale asked the participant to report the extent to which they experienced various potentially stressful events in the previous month (e.g. 'how often have you found that you could not cope with all the things that you had to do?'). Participants responded on a 5-point scale ranging from 'never' (0) to 'very often' (4). Four positively worded items were reverse scored and the score for each item summed to yield a total score ranging between 0 and 40, with a higher score indicative of greater background stress.

Bond-Lader Visual Analogue Scales (VAS). The VAS (Bond & Lader, 1974) required participants to rate their level of 'alertness', 'contentedness', and 'calmness' on 16 bipolar scales. In the amended version used here, four further single item measures were included to gauge participants' self-reported levels of 'anxiousness', 'relaxedness', 'stressfulness' and 'happiness'. The ratings were made by placing a mark at the relevant point on a 100 mm line, with the end of each line reflecting the extremes of the dimension being rated (e.g. ‘alert’ versus ‘drowsy’). A higher score indicates a higher level of the relevant dimension.

State-Trait Anxiety Inventory (STAI). The STAI (Spielberger, 1983) incorporates two 20-item subscales, measuring a) state anxiety and b) trait anxiety. For the purposes of the present study, only the state anxiety items of the STAI were administered. The state anxiety subscale of the STAI required participants to rate how they ‘feel right now’ with respect to 20 statements on a four-point scale (‘not at all’, ‘somewhat’, ‘moderately so’, ‘very much so’). Positively worded items (e.g. ‘I feel calm’) were reverse scored, so that a score of 4 for an individual item represented the highest level of anxiety. A total score was calculated by summing together the scores for each of the items.

Stress and Arousal Checklist (SACL). The SACL (Mackay et al., 1978) is a list of 34 adjectives relating to psychological stress (e.g. ‘tense’) and arousal (e.g. ‘alert’). The stress subscale comprised 19 items and the arousal scale comprised 15 items. Participants responded as to whether they ‘definitely feel’, ‘slightly feel’, ‘can’t decide’ or ‘definitely do not feel’ each adjective at the moment of responding. For negative items on the stress scale, a score of 1 was attributed to each item to which the participant responded ‘definitely feel’ or ‘slightly feel’, and scores were summed to yield a total score ranging between 0 and 19, with higher scores indicative of greater levels of stress. For positive items on the arousal scale, a score of 1 was attributed to each item to which the participant responded ‘definitely feel’ or ‘slightly feel’, and scores were summed to yield a total score ranging between 0 and 15, with higher scores indicative of greater levels of arousal.

National Aeronautics and Space Administration Task Load Index (NASA-TLX). The NASA-TLX (Hart & Staveland, 1988) is a six item pencil-and-paper measure of perceived workload. The six items measured ‘mental demand’, ‘physical demand’, ‘temporal demand’, ‘effort’, ‘performance’ and ‘frustration’. Participants responded using a visual analogue scale in which responses are made by placing a mark at the relevant point on a 100 mm line. ‘Low’ and ‘high’ were used as the anchor points at each end of the line. A separate score was derived for each individual item.

Cardiovasular monitoring equipment. Systolic (SBP) and diastolic (DBP) blood pressure were measured using Portapres (Smart Medical, Moreton in Marsh, UK), a non-invasive, continuous beat-to-beat blood pressure monitoring system. Finger arterial BP was monitored via an inflatable finger cuff fitted to the finger of the hand opposite to that which the participant typically uses to operate a mouse. Heart rate (HR) was monitored using a Polar chest strap HR monitor (Polar Electro, Warwick, UK). The Portapres and Polar signals were relayed online to a Powerlab data acquisition hardware unit (AD Instruments, Oxford, UK), and were saved and analysed using LabChart 7 software (AD Instruments, Oxford, UK).

Procedure

The study was approved prior to commencement by the Northumbria University Faculty of Health and Life Sciences Ethics Committee. Participants first completed the DS16, PSS, VAS, STAI and SACL, before being fitted with the Protapres finger cuff and Polar chest strap. Cardiovascular activity was monitored for a five minute baseline period. Cardiovascular recordings continued during a subsequent ‘demo’ period, during which the Multitasking Framework was explained to participants and participants completed a two minute demonstration of the task with instruction from the researcher. Specifically, participants were told that they must be as fast and accurate on all of the tasks as possible, in order to achieve as high a score as they could. Following the demo period and the answering of any questions about the task, participants completed the Multitasking Framework for a 20 minute period, during which beat-to-beat HR and BP were measured. Immediately following the task, cardiovascular measures were recorded during a five minute ‘recovery period’, during which the NASA-TLX, VAS, STAI and SACL were completed by the participant.

Treatment of data

Any participants who failed to respond in at least 75% of trials on each module of the Multitasking Framework were deemed not to have engaged with multitasking as instructed, and were excluded from all analyses. Participants were also excluded from analyses of the cardiovascular data if artefact in the HR or BP signal was detected at processing.

Initial analyses comprised an independent samples t-test being performed for each outcome variable using the traditional dichotomous typology, with individuals characterised as Type D and non-Type D being compared. Individuals were classified as Type D if their score was above the median for both NA (median = 9) and SI (median = 12).

A correlational analysis was then performed between Type D personality (the NA x SI interaction term) and the outcome measures (self-report and cardiovascular) to investigate the linear relationship between the continuous Type D construct and the outcome measures. Finally hierarchical regression analyses were performed, in which NA and SI were entered as predictors in step 1, to ascertain the influence of these two facets of Type D personality on the outcome variable. The NA x SI interaction term was added at step 2, to determine whether the synergistic effect of these two dimensions have a predictive value on the outcomes under investigation that is significantly greater than that of NA and SI when considered in isolation.

Results

Stress manipulation check

In order to establish that the Multitasking Framework was an effective stressor, a series of paired samples t-tests were performed between the ‘pre’ and ‘post’ stressor self-report measures. A significant difference was detected for all self-report measures (all *p*s < 0.05), with the exception of two of the single item measures on the VAS, namely anxiousness ($p = 0.35$) and happiness ($p = 0.20$). Additionally a repeated measures ANOVA was performed on the cardiovascular data to compare the means for each time-point. The Multitasking Framework induced significant changes in SBP, F (3, 60) = 14.81, $p < 0.001$, with Bonferroni adjusted pairwise comparisons revealing that SBP during the demo ($p < 0.001$), task ($p < 0.001$) and recovery ($p < 0.001$) phases was greater than at baseline. The Multitasking Framework also induced significant changes in DBP, F (3, 60) = 11.54, $p < 0.001$, with Bonferroni adjusted pairwise comparisons revealing that DBP during the demo ($p < 0.01$), task ($p < 0.001$) and recovery ($p < 0.001$) phases was greater than at baseline, and DBP during the demo was lower than during the task ($p < 0.01$) and during recovery ($p < 0.001$). There was no significant difference in HR between the four time-points, F (3, 58) = 2.05, $p = 0.12$ (see Table 1 for descriptive statistics).

INSERT TABLE 1 ABOUT HERE

Comparison of Type D and non-Type D using a dichotomous typology

Of the 67 participants who provided usable data, 14 (20.9%) were classified at Type D. Type D individuals reported higher levels of background stress on the PSS, t (65) = -2.32, $p < 0.05$ ($M_{\text{Type D}} = 18.8$, $SD_{\text{Type D}} = 3.9$; $M_{\text{Non-type D}} = 15.2$, $SD_{\text{Non-type D}} = 5.3$). Type D individuals also reported lower levels of contentedness pre-stress exposure, t (65) = 2.71, $p < 0.01$ ($M_{\text{Type D}} = 68.4$, $SD_{\text{Type D}} = 10.8$; $M_{\text{Non-type D}} = 76.7$, $SD_{\text{Non-type D}} = 10.0$), lower levels of relaxedness post-stress exposure, t (65) = 2.58, $p < 0.05$ ($M_{\text{Type D}} = 40.9$, $SD_{\text{Type D}} = 19.0$; $M_{\text{Non-type D}} = 55.7$, $SD_{\text{Non-type D}} = 19.2$), and higher levels of state anxiety post-stress exposure, t (64) = -2.03, $p < 0.05$ ($M_{\text{Type D}} = 40.2$, $SD_{\text{Type D}} = 6.7$; $M_{\text{Non-type D}} = 35.6$, $SD_{\text{Non-type D}} = 7.5$).

Differences between the Type D and non-Type D groups were nonsignificant for all further self-report measures, and for all of the cardiovascular measures.

Correlational analysis using continuous Type D construct

Self-report outcomes. There was a significant positive relationship between Type D and perceived background stress, $r = 0.44$, $p < 0.001$. On the VAS, there was a significant negative relationship between Type D and contentedness both pre-, $r = -0.50$, $p < 0.001$; and post,- $r = -0.28$, $p < 0.05$, stress exposure. Further, there was a significant negative relationship between Type D and alertness pre-stress exposure, $r =- 0.35$, $p < 0.01$; and also between Type D and relaxedness post-stress exposure, $r = -0.31$, $p = 0.01$. State anxiety was positively related to Type D both pre-, $r = 0.31$, $p < 0.05$; and post-, $r = 0.30$, $p < 0.05$, exposure to the stressor. There were no significant relationship between Type D and either stress or arousal, as measured by the SACL. Further, there were no significant relationships between Type D and any of the perceived workload variables (see Table 2).

Physiological Outcomes. There was no significant relationship between the continuous Type D construct and either HR, SBP or DBP at any of the four time-points under investigation (baseline, demo, task, recovery).

INSERT TABLE 2 ABOUT HERE

Perceived Stress Scale

NA and SI accounted for 27.4% of the variance in PSS scores, with this regression model being significant, F (2, 66) = 12.08, $p < 0.001$. NA ($\beta = 0.28$, $p < 0.05$) and SI ($\beta = 0.34$, $p < 0.01$) were both significant predictors of PSS scores. The addition of the NA x SI interaction term at Step 2 accounted for a further 3.6% of the variance in PSS, which failed to reach significance, F (1, 63) = 3.31, $p = 0.07$ (see Table 3).

Pre-stress self-report measures

NA was a significant predictor of alertness at Step 1 (β = -0.68, $p < 0.05$), with this overall regression model predicting a significant amount of the variance in alertness, R^2 = 0.177, F (2, 66) = 6.89, $p < 0.01$. The overall regression model was also significant at Step 2, F (3, 66) = 5.02, $p < 0.01$ but the NA x SI interaction term did not significantly predict additional variance in alertness, $\Delta R^2 = 0.016$, F (1, 63) = 1.23, $p = 0.27$. A similar finding was observed for contentedness, with NA being a significant predictor (β = -0.47, $p < 0.001$) within a significant regression model at Step 1, $R^2 = 0.279$, F (2, 66) = 12.39, $p < 0.001$, and the regression model also being significant at Step 2, with the NA x SI interaction term not adding significantly predicting any additional variance in contentedness, $\Delta R^2 = 0.001$, F (1, 63) = 0.13, $p = 0.72$. SI was a significant predictor of relaxedness (β = 0.37, $p < 0.01$), with the Step 1 regression model being significant, F (2, 66) = 4.45, $p < 0.05$ and explaining 12.2% of the variance in relaxedness. The addition of the NA x SI interaction term at Step 2 explained a further 6.6% of the variance in relaxedness, F (1, 63) = 5.11, $p < 0.05$, with the interaction term being a significant predictor of relaxedness (β = -0.93, $p < 0.05$), and the overall regression model being significant, F (3, 66) = 4.86, $p < 0.01$. NA was a significant predictor of state anxiety at Step 1 (β = 0.40, $p < 0.01$), with this overall regression model predicting a significant amount of the variance in state anxiety, $R^2 = 0.158$, F (2, 66) = 6.00, $p < 0.01$. The overall regression model was also significant at Step 2, F (3, 66) = 4.20, $p < 0.01$ but the NA x SI interaction term did not significantly predict additional variance in state anxiety, $\Delta R^2 = 0.009$, F (1, 63) = 0.65, $p = 0.42$. Hierarchical regression analyses did not reveal any significant prediction of calmness, anxiousness, stressfulness, happiness, SACL arousal or SACL stress by NA, SI or the NA x SI interaction term during the pre-stress period (see Table 3).

Post-stress self-report measures

SI was a significant predictor of anxiousness at Step 1 (β = 0.37, $p < 0.01$), with this overall regression model predicting a significant amount of the variance in alertness, R^2 = 0.117, F (2, 66) = 4.22, $p < 0.05$. The overall regression model was also significant at Step 2, F (3, 66) = 2.84, $p < 0.05$ but the NA x SI interaction term did not significantly predict additional variance in alertness, $\Delta R^2 = 0.003$, F (1, 63) = 0.19, $p = 0.66$. NA and SI accounted for 6.8% of the variance in relaxedness, with this regression model failing to reach significance, F (2, 66) = 2.34, $p = 0.10$. The addition of the NA x SI interaction term at Step 2 accounted for a further 5.7% of the variance in baseline SBP, which was a significant increase in variance explained, F (1, 63) = 4.10, $p < 0.05$. SI was a significant predictor of stressfulness at Step 1 (β = 0.36, $p < 0.01$), with this overall regression model predicting a significant amount of the variance in stressfulness, R^2 = 0.109, F (2, 66) = 3.90, $p < 0.05$. The overall regression model was also significant at Step 2, F (3, 66) = 2.77, $p < 0.05$ but the NA x SI interaction term did not significantly predict additional variance in stressfulness, ΔR^2 = 0.008, F (1, 63) = 0.57, $p = 0.45$. NA and SI accounted for 10.6% of the variance in state anxiety, with this regression model being significant, F (2, 65) = 3.72, $p < 0.05$. However, NA (β = 0.17, $p = 0.20$) and SI (β = 0.22, $p < 0.10$) both failed to reach significance in terms of independent prediction of state anxiety. The addition of the NA x SI interaction term at Step 2 accounted for a further 0.1% of the variance in state anxiety, which failed to reach significance, F (1, 62) = 0.05, $p = 0.82$. NA and SI accounted for 2.8% of the variance in SACL stress, with this regression model failing to reach significance, F (2, 66) = 0.93, p = 0.40. The addition of the NA x SI interaction term at Step 2 accounted for a further 6.1% of the variance in baseline SBP, which was a significant increase in variance explained, F (1, 63) = 4.20, $p < 0.05$. Hierarchical regression analyses did not reveal any significant prediction of alertness, contentedness, calmness, happiness or SACL arousal by NA, SI or the NA x SI interaction term during the post-stress period (see Table 3).

INSERT TABLE 3 ABOUT HERE

Perceived workload

Hierarchical regression analyses did not reveal any significant prediction of any of the perceived workload outcomes by NA, SI or the NA x SI interaction term.

Cardiovascular measures

Heart Rate. Hierarchical regression analyses did not reveal any significant prediction of HR by NA, SI or the NA x SI interaction term during any of the four sampling periods.

Systolic Blood Pressure. During the baseline period, NA and SI accounted for 0.2% of the variance in SBP, with this regression model failing to reach significance, F (2, 64) = 0.06, $p = 0.94$. The addition of the NA x SI interaction term at Step 2 accounted for a further 6.5% of the variance in baseline SBP, which was a significant increase in variance explained, F (1, 61) = 4.23, $p < 0.05$. Similarly, during the demo period, NA and SI did not significantly explain the variance in SBP, $R^2 = 0.006$, F (2, 63) = 0.06, $p = 0.94$, but addition of the interaction term significantly increased the variance explained, $\Delta R^2 = 0.072$, F (1, 60) = 4.66, $p < 0.05$. This pattern was also observed for SBP during the task, with the 0.4% of the variance explained in Step 1 being nonsignificant, F (2, 64) = 0.13, $p = 0.88$, but the additional 6.8% of the variance explained via the addition of the NA x SI interaction term being significant, F (1, 61) = 4.19, $p < 0.05$. Hierarchical regression analyses did not reveal any significant prediction of SBP by NA, SI or the NA x SI interaction term during the recovery period.

Diastolic Blood Pressure. Hierarchical regression analyses did not reveal any significant prediction of DBP by NA, SI or the NA x SI interaction term during the baseline period. During the demo period, NA and SI accounted for 1.2% of the variance in DBP, with this regression model failing to reach significance, F (2, 63) = 0.36, p = 0.70. The addition of the NA x SI interaction term at Step 2 accounted for a further 15.3% of the variance in baseline DBP, which was a significant increase in variance explained, F (1, 60) = 10.97, p < 0.01. The overall regression model was significant at Step 2, F (3, 63) = 3.93, p < 0.05, with NA (β = 1.15, p = 0.001), SI (β = 0.80, p < 0.01) and the NA x SI interaction term (β = -1.57, p < 0.01) all being significant predictors of DBP. Similarly, during the task, NA and SI did not significantly explain the variance in DBP, R^2 = 0.017, F (2, 64) = 0.52, p = 0.60, but addition of the interaction term at Step 2 significantly increased the variance explained, ΔR^2 = 0.104, F (1, 61) = 7.21, p < 0.01. The overall regression model was significant at Step 2, F (3, 64) = 2.79, p < 0.05, with NA (β = 0.94, p = 0.01) and the NA x SI interaction term (β = -1.30, p < 0.01) both being significant predictors of DBP. During the recovery period, NA and SI explained 1.1% of the variance in DBP, with the regression model for Step 1 being nonsignificant, F (2, 62) = 0.32, p = 0.72, but the additional 11.1% of the variance explained via the addition of the NA x SI interaction term was significant, F (1, 59) = 7.46, p < 0.01 (see Table 4).

INSERT TABLE 4 ABOUT HERE

Discussion

The primary aim of the present study was to investigate the influence of Type D personality on cardiovascular reactivity to stress in healthy adults. It is important to address this research question in order to partially support the notion that dysregulated psychobiological reactivity to stress is a mechanistic underpinning of the heightened risk of later life adverse health outcomes from coronary heart disease in Type D individuals. A novel feature of this study was that the stressor which we employed was an ecologically valid Multitasking Framework, which reflects the kinds of multitasking demands that an individual might be faced with and potentially stressed by in the real world. An inverse relationship was observed between the continuous Type D construct and cardiovascular reactivity to the stressor, while NA, SI and the continuous Type D construct were found to be associated with self-reported mood before and after exposure to the stressor, as well as with background stress. The conceptualisation of Type D as a dimensional construct demonstrated superior predictive value than the dichotomous Type D typology, but in the regression models, the interactive Type D construct accounted for limited additional variance in the self-report outcomes above that of NA and SI when considered in isolation. However, the continuous Type D construct was found to significantly predict BP after controlling for its constituent components, NA and SI. These findings will be discussed in further detail herein.

Using the dichotomous typology, Type D individuals reported relatively higher levels of background stress than non-Type D participants. This finding was confirmed by the correlation analyses, which suggested a strong positive relationship between background stress (PSS scores) and Type D personality (the NA x SI interaction term). However, it is evident from the regression analyses that while both NA and SI were strong predictors of background stress (together accounting for 27.4% of the variance in background stress), the NA x SI interaction term did not significantly increase the variance explained by NA and SI when these components were considered independently of the Type D interaction term. This suggests that NA and SI, considered independently, may be better predictors of background stress than the Type D personality construct.

With regard to the pre- and post-stress self-report measures, Type D was related to lower pre-stress contentedness, lower post-stress relaxedness and higher post-stress anxiety, according to both the dichotomous and continuous correlational analyses. This finding suggests a reasonable concordance between the predictive value of both the dichotomous Type D typology and the continuous Type D construct for self-reported mood before and after exposure to an ecologically valid stressor. However, Type D personality was also associated with decreased alertness and increased anxiety prior to stress exposure, as well as lower contentedness post-stress exposure, according to the findings of the correlation analysis. This suggests that a dimensional conceptualisation of the Type D construct improves its capacity for predicting self-report mood in relation to stress exposure. While the correlation analyses were suggestive of some robust relationships between Type D and mood which broadly replicated the subjective stress findings of Williams and colleagues (2009), there was little evidence from the regression analyses that the Type D construct provides additive predictive value of mood from that of NA and SI. NA was found to be a robust predictor of mood prior to stress exposure, as NA was negatively associated with alertness and positively associated with stress, contentedness and anxiety. This finding suggests that high NA individuals may experience more stress in relation to the anticipation of forthcoming potentially stressful events. This is an assertion that warrants attention in future research. In addition, SI independently predicted self-reported stress and anxiety following exposure to the stressor, suggesting that socially inhibited individuals may experience greater stress and anxiety as a result of exposure to stress. However, despite NA and SI demonstrating sound predictive value of self-report mood, the additive value of the continuous Type D construct in the prediction of the mood variables was relatively less robust. The NA x SI interaction term was a significant predictor of stress (as measured by the SACL) following the stressor, but the 8.9% of the variance explained in post-Framework stress by NA, SI and the NA x SI interaction term was nonsignificant. The NA x SI interaction term was also negatively associated with relaxedness both pre- and post-stress exposure, but this finding needs to be treated with caution due to the influence of an unexpected positive relationship between SI and relaxedness on the regression model. On the basis of the three analysis techniques employed, it can be concluded that the continuous Type D construct is a better predictor of mood in relation to stress exposure than the dichotomous typology, but the regression analyses suggest that the continuous Type D construct has only limited additive predictive value than that of its NA and SI constituents considered independently.

It was somewhat surprising that neither Type D nor its constituent factors predicted perceived workload in relation to the stressor. The Multitasking Framework has previously been associated with increased perceived workload as the demands of the stressor increase (Wetherell & Carter, in press). Anecdotally, it was expected that Type D individuals, who by their nature tend to be relatively irritable (Denollet, 2005), would find the multitasking stressor more frustrating and perhaps more mentally demanding. Future work should perhaps consider varying the intensity of the stressor, with the aim of investigating whether there is an intensity threshold at which Type D individuals become more frustrated by multitasking performance.

The primary aim of the present study was to investigate the influence of Type D personality on cardiovascular reactivity to an ecologically valid multitasking stressor. No significant relationships were observed between HR and Type D. Further, no significant associations were observed between the continuous Type D construct and the cardiovascular parameters in the correlation analyses. By contrast, in the regression analyses, the NA x SI interaction term emerged as a significant predictor of BP, with an inverse relationship being detected between the NA x SI interaction term and i) SBP at baseline and demo, and ii) DBP during the demo, task and recovery phases. All of these effects were detected at Step 2, in which NA, SI and the NA x SI interaction term were all entered into the model. On this basis, it appears that the continuous Type D construct (controlling for the influences of its constituent components) was predictive of a reduced cardiovascular response to the stressor itself, and to the anticipatory stress during the baseline period, when anticipation of the forthcoming task demands would have been at their peak. Predicated by previous research which has observed a positive relationship between Type D and the cardiovascular response to stress in healthy young adults (Kupper et al., 2013b; Williams et al., 2009), we may have expected to observe a similar pattern of results here in response to our ecologically valid multitasking stressor. However, the relationship observed between the continuous Type D construct and BP was suggestive of more ‘blunted’ BP reactivity with increasing ‘Type Dness’. These findings are in line with previous studies which have observed blunted BP reactivity to mental arithmetic in well-rested Type D individuals (Howard et al., 2011; O'Leary et al., 2013) and public speaking in heart failure patients (Kupper et al., 2013a). It has recently been suggested that a blunted cardiovascular response to stress is associated with adverse health outcomes (Phillips et al., 2013), thus the present study finding of an inverse relationship between the NA x SI interaction term and BP reactivity to the stressor may provide a mechanistic explanation for adverse health outcomes in Type D individuals.

One plausible interpretation of the adverse influence of Type D (and personality more generally) on health outcomes both here and elsewhere, is reverse causality (Friedman, 2000). For example, with respect to self-report measures, individuals high on traits such as neuroticism (and by extension NA) may be biased towards greater reporting of negative physical symptoms and stress (Friedman, 2000). In line with this argument, it is possible that individuals with an attenuated cardiovascular response to stress develop a behavioural style reflected by high NA and SI. As many studies in this area are cross-sectional, it is difficult to rule out this reverse causality account of the relationship between Type D and cardiovascular function. But given our speculation that Type D influences on cardiovascular reactivity in healthy young individuals may be the mechanism by which Type D is associated with adverse coronary and other health outcomes in later life, prospective investigations may also be unable to account for this reverse causality interpretation.

Strengths of the present study included the use of an ecologically valid stressor and the optimal approach to the measurement of HR and BP involving the collection of beat-to-beat data throughout the testing session. However, the study must be considered in light of its limitations. Firstly, the baseline period was not a 'true' baseline in that the baseline measures were obtained immediately prior to onset of the stressor. Therefore, the level of stress experienced during this phase of the study was likely to be greater than basal levels of stress due to the anticipation of the forthcoming stressor. While this aspect of the study design did enable us to investigate the influence of Type D on anticipatory stress, it did not allow for 'change from baseline' indices to be calculated to obtain pure measures of reactivity to the stressor, as any stress-related effects of Type D could have been due to both basal and reactivity effects. A further limitation is that, for logistical reasons, we were unable to standardise the time of day at which testing took place in the present study. While diurnal variation in mood and cardiovascular activity could have confounded the observations reported here, we ensured that testing took place between 9am and 5pm, to avoid any potential fatigue effects of very early morning or evening testing. A final limitation is that we employed the older Type D questionnaire (DS16) to measure Type D personality rather than the relatively newer DS14 (Denollet, 2005). While the items on these two instruments are similar and both comprise NA and SI subscales, the DS16 has not been developed in such a way that standardised cut-offs for defining Type D personality are provided (as is the case with the DS14). While this is not likely to have been a substantial issue for the dimensional analyses in which Type D and non-Type D groups are not defined, in the present study median splits on the NA and SI subscales were used to define the Type D group for the dichotomous analyses. Our dichotomous findings may therefore not be directly comparable to recent Type D studies due to the less psychometrically appropriate approach which was employed for defining Type D.

The present study has provided support for an association between mood in relation to ecologically valid laboratory stress exposure and the components of Type D personality. Future research in this area should seek to extend these findings by investigating the relationship between Type D personality and psychobiological reactivity paradigms with even greater ecological validity than that of multitasking. Such paradigms could include exposure to potentially life-threatening stressors, such as extreme sports (e.g. Hare et al., 2013). It would potentially be of even greater interest to better understand whether the negative associations between mood and Type D observed during the pre-stress period both in the present study, and elsewhere (Williams et al., 2009) are attributable to a general reduction in basal mood in Type D individuals, or whether this reduction in pre-stress mood is specifically related to anticipation of the stressor. If it were to transpire that Type D personality is associated with increased anticipatory stress in relation to potential forthcoming demands, this in itself could be a mechanism by which Type D personality amplifies the risk for adverse coronary health outcomes in later life. Further work is also needed to investigate the mechanisms underpinning the observed inverse relationship between Type D and blood pressure reactivity observed both here, and elsewhere (Howard et al., 2011; Kupper et al., 2013a; O'Leary et al., 2013). Future studies should aim to establish the precise nature of the relationship between Type D personality and blunted BP reactivity (including whether this relationship is consistent for different types of stressors), and should also investigate whether blunted BP reactivity is a mechanism underpinning the adverse health consequences associated with Type D personality.

We here sought to investigate whether Type D personality is associated with cardiovascular reactivity to an ecologically valid laboratory stressor. Conceptualisation of Type D as a dimensional construct yielded greater predictive value of mood than the traditional dichotomous approach. However, this dimensional conceptualisation of Type D personality explained limited further variance in the self-report outcomes than the NA and SI components alone. Further, Type D was inversely associated with cardiovascular reactivity to multitasking stress. This observation is consistent with previous research which has observed blunted BP reactivity to stress in Type D individuals (Howard et al., 2011; Kupper et al., 2013a; O'Leary et al., 2013), and given that blunted cardiovascular reactivity to stress is associated with adverse health outcomes (Phillips et al., 2013), may provide a mechanistic explanation for adverse health consequences in this group. In conclusion, NA and SI may be better independent predictors of mood and background stress than the Type D construct. However, the present study found support for the notion of blunted cardiovascular reactivity to ecologically valid laboratory stress as Type D personality increases (when Type D is conceptualised as the continuous interaction between NA and SI, controlling for the individual influence of NA and SI). On this basis, it is suggested here that a dimensional conceptualisation of Type D, controlling for the individual influences of NA and SI, is most useful in terms of the likelihood of observing a relationship between Type D personality and cardiovascular reactivity to stress.

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Table 1

Means (and standard deviations) for the self-report and physiological data at each time-point

	Baseline	Demo	Task	Recovery
Alertness (VAS)	61.4 (13.7)			66.7 (14.2)
Contentedness (VAS)	75.0 (10.6)			68.8 (13.5)
Calmness (VAS)	66.7 (16.4)			49.1 (18.9)
Anxiousness (VAS)	25.5 (19.2)			28.2 (19.7)
Relaxedness (VAS)	62.8 (19.9)			52.6 (20.0)
Stressfulness (VAS)	28.8 (19.2)			37.8 (20.9)
Happiness (VAS)	66.3 (18.4)			62.3 (20.8)
State Anxiety (STAI)	32.4 (6.9)			36.5 (7.5)
Arousal (SACL)	8.3 (4.6)			9.6 (3.9)
Stress (SACL)	2.6 (3.2)			3.6 (3.6)
HR (BPM)	81.4 (10.1)	78.8 (12.9)	78.4 (15.6)	81.0 (11.0)
SBP (mmHg)	127.8 (18.7)	134.6 (17.6)	136.5 (18.8)	136.0 (18. 8)
DBP (mmHg)	70.0 (14.1)	74.1 (9.8)	76.4 (9.7)	77.6 (9.7)

Table 2

Correlations between Type D (NA x SI) and self-report measures

	Pre-stress		Post-stress	
	r	*p*	*r*	*p*
Background stress				
PSS-10	0.44	< 0.001***		
Self-report state measures				
Alertness (VAS)	-0.35	0.003**	-0.12	0.31
Contentedness (VAS)	-0.50	< 0.001***	-0.28	0.02*
Calmness (VAS)	0.05	0.68	-0.09	0.47
Anxiousness (VAS)	0.05	0.71	0.15	0.23
Relaxedness (VAS)	0.16	0.19	-0.31	0.01*
Stressfulness (VAS)	0.02	0.90	0.16	0.19
Happiness (VAS)	-0.16	0.19	0.01	0.96
State Anxiety (STAI)	0.31	0.01*	0.30	0.01*
Arousal (SACL)	-0.16	0.18	-0.10	0.40
Stress (SACL)	0.03	0.19	0.22	0.08
Perceived workload (NASA-TLX)				
Mental Demand			-0.02	0.87
Physical Demand			-0.05	0.68
Temporal Demand			0.07	0.56
Effort			0.07	0.59
Performance			-0.11	0.38
Frustration			0.10	0.42

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 3

Hierarchical regression analyses predicting self-report outcomes

		Pre-Stress		Post-Stress	
		β	R^2 (ΔR^2)	β	R^2 (ΔR^2)
Background stress (PSS)					
Step 1	NA	0.28*			
	SI	0.34**	0.274***		
Step 2	NA	0.73**			
	SI	0.67**			
	NA x SI	-0.69	0.310*** (0.036)		
Alertness (VAS)					
Step 1	NA	-0.38**		0.05	
	SI	-0.08	0.177**	-0.24	0.051
Step 2	NA	-0.68*		-0.10	
	SI	-0.30		-0.35	
	NA x SI	0.45	0.193** (0.016)	0.22	0.055 (0.004)
Contentedness (VAS)					
Step 1	NA	-0.47***		-0.10	
	SI	-0.12	0.279***	-0.23	0.079
Step 2	NA	-0.38		0.15	
	SI	-0.05		-0.04	
	NA x SI	-0.14	0.281*** (0.001)	-0.38	0.090 (0.011)
Calmness (VAS)					
Step 1	NA	-0.02		< -0.01	
	SI	0.06	0.003	-0.04	0.002

Step 2	NA	-0.28		0.48	
	SI	-0.14		0.32	
	NA x SI	0.39	0.014 (0.012)	-0.74	0.044 (0.042)
Anxiousness (VAS)					
Step 1	NA	0.11		-0.17	
	SI	-0.04	0.009	0.37**	0.177*
Step 2	NA	0.23		-0.30	
	SI	0.05		0.28	
	NA x SI	-0.18	0.012 (0.003)	0.19	0.119* (0.003)
Relaxedness (VAS)					
Step 1	NA	-0.05		-0.22	
	SI	0.37**	0.122*	-0.08	0.068
Step 2	NA	0.55		0.34	
	SI	0.82**		0.34	
	NA x SI	-0.93*	0.188** (0.066*)	-0.86*	0.125* (0.057*)
Stressfulness (VAS)					
Step 1	NA	0.20		-0.16	
	SI	-0.22	0.051	0.36**	0.109*
Step 2	NA	0.11		-0.37	
	SI	-0.28		0.20	
	NA x SI	0.13	0.053 (0.001)	0.32	0.117* (0.008)
Happiness (VAS)					
Step 1	NA	-0.21		0.03	
	SI	0.08	0.036	0.06	0.006
Step 2	NA	0.19		0.59	

	SI	0.38		0.48	
	NA x SI	-0.61	0.064 (0.028)	-0.86	0.062 (0.056)
State Anxiety (STAI)					
Step 1	NA	0.40**		0.17	
	SI	-0.01	0.158**	0.22	0.106*
Step 2	NA	0.62*		0.24	
	SI	0.15		0.27	
	NA x SI	-0.34	0.167** (0.009)	-0.10	0.106 (0.001)
Arousal (SACL)					
Step 1	NA	-0.17		0.06	
	SI	-0.04	0.035	-0.17	0.023
Step 2	NA	-0.24		0.27	
	SI	-0.09		-0.01	
	NA x SI	0.10	0.036 (0.001)	-0.32	0.031 (0.008)
Stress (SACL)					
Step 1	NA	0.04		0.04	
	SI	-0.01	0.001	0.14	0.028
Step 2	NA	-0.07		-0.54	
	SI	-0.09		-0.29	
	NA x SI	0.16	0.003 (0.002)	0.89*	0.089 (0.061*)

* $p < 0.05$; ** $p < 0.01$

Table 4

Hierarchical regression analyses predicting blood pressure

		Baseline		Demo		Task		Recovery	
		β	R^2 (ΔR^2)	β	R^2 (ΔR^2)	β	R^2 (ΔR^2)	β	R^2 (ΔR^2)
Systolic									
Step 1	NA	-0.03		-0.03		-0.03		-0.14	
	SI	0.05	0.002	0.08	0.006	-0.04	0.004	-0.02	0.024
Step 2	NA	0.65		0.68		0.64		0.44	
	SI	0.56		0.63*		0.47		0.43	
	NA x SI	-1.02*	0.067 (0.065*)	-1.08*	0.078 (0.072*)	-1.02	0.068 (0.064*)	-0.89	0.073 (0.049)
Diastolic									
Step 1	NA	-0.04		0.11		0.08		-0.01	
	SI	0.03	0.002	< 0.01	0.012	-0.13	0.017	-0.10	0.011
Step 2	NA	0.55		1.15**		0.94**		0.87*	
	SI	0.48		0.80**		0.52		0.58*	
	NA x SI	-0.89	0.051 (0.049)	-1.57**	0.164* (0.153**)	-1.30**	0.121* (0.104**)	-1.33**	0.122 (0.111**)

* $p < 0.05$; ** $p < 0.01$

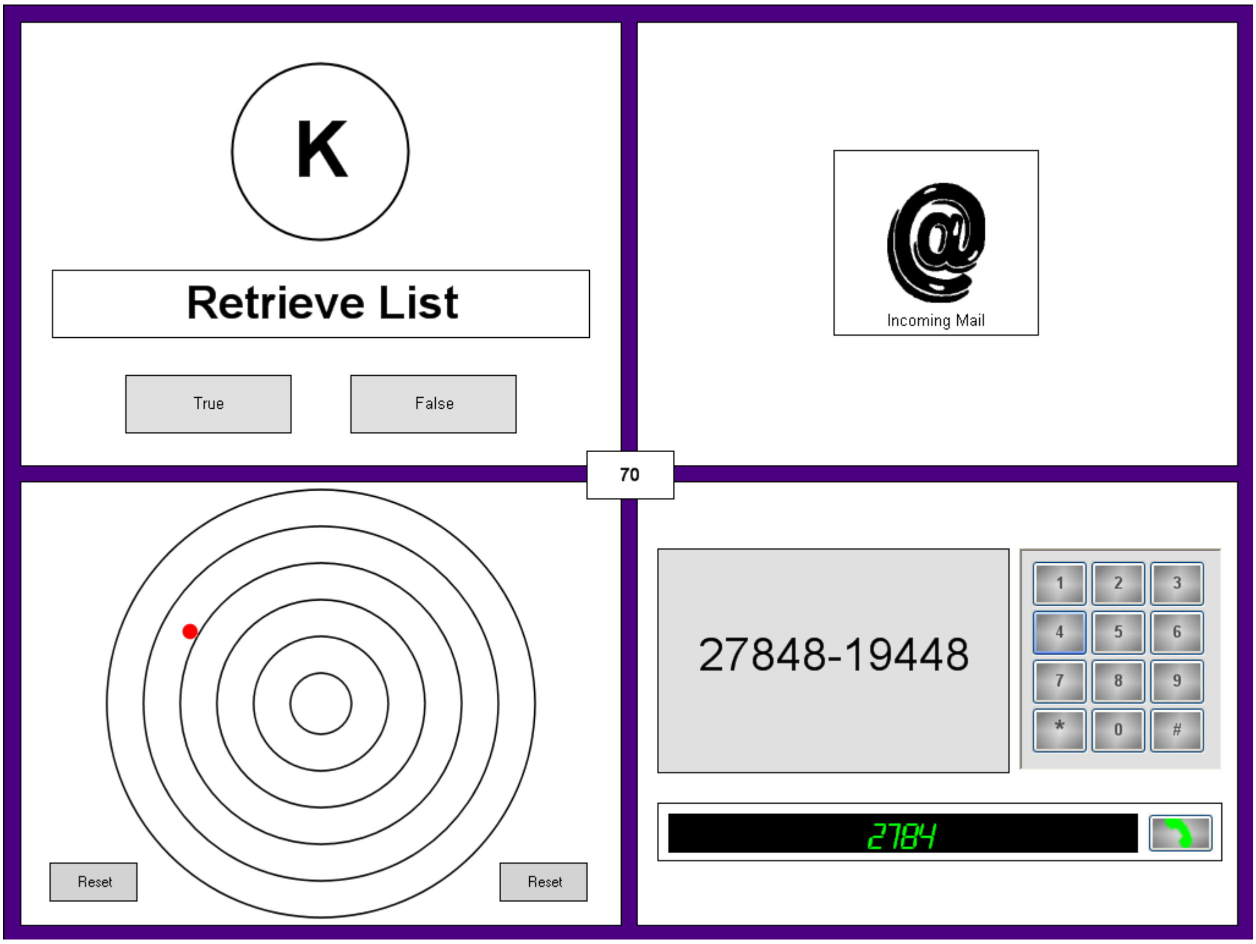

Figure 1

Screen grab of the Multi-Tasking Framework showing the four modules that were employed in the present study (clockwise from top left: Letter Search, Mail Alert, Telephone Number Entry, Target Tracker). The participant's total framework score is displayed in the centre of the screen.