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Abstract

This study investigated the influence of different types of mental imagery on heart rate and anxiety responses to a standard psychological stress task. Using a within-design, 25 females (M_{age} = 23.24; *SD* = 4.19) imaged three different scripts (challenge, threat, and neutral) to manipulate appraisal of a speech preparation task. Following each script, participants completed the task. Heart rate was recorded during a resting baseline prior to each imagery script and during each speech preparation task. Cognitive and somatic anxiety and self-confidence were assessed prior to the speech preparation trials, and immediately prior to each speech preparation following imagery. Following threat imagery, participants reported the speech preparation task to be significantly more stressful and threatening, and experienced lower levels of confidence and more negative interpretations of their anxiety symptoms compared with the challenge and neutral imagery conditions. Additionally, there was a significantly greater increase in heart rate following threat imagery compared with challenge and neutral imagery. Findings demonstrate that imagery can alter stress appraisal and the accompanying cardiovascular and psychological responses to standardized stress tasks. Imagery interventions, acknowledging the stressful nature of events, but emphasising feelings of efficacy and control are likely to lead to more adaptive coping.

Keywords: anxiety; coping; mental imagery; bioinformational theory; stress appraisal

Challenge and Threat Imagery Manipulates Heart Rate and Anxiety Responses to Stress

Psychological and cardiovascular responses to psychological stress can have detrimental effects on health, wellbeing, and performance (e.g., Adams, 1980; Chida, & Steptoe, 2010; Moore, Vine, Wilson, Freeman, 2012; Sarason & Sarason, 1984). Consequently, techniques such as mental imagery are frequently employed to assist with the treatment of fears, phobias, and posttraumatic stress disorders to reduce the negative consequences (Arntz & Weertman, 1999; Holmes, Arntz, & Smucker, 2007; Wild, Hackmann, & Clark, 2007). Mental imagery, described as the internal creation (or re-creation) of thoughts and feelings (Cumming & Williams, 2012), can also improve coping and performance in stressful situations such as sporting competitions, unfamiliar tasks, and pressurized training (Evans, Jones, & Mullen, 2004; Hanton & Jones, 1999; Jing, Wu, Liu, Wu, & Miao, 2011; Jones, Mace, Bray, MacRae, & Stockbriedge, 2002). Imagery has also been shown to reduce stress and anxiety in individuals experiencing stressful life events such as child birth, chemotherapy, and inflammatory bowel disease (Charalambous, Giannakopoulou, Bozas, & Paikousis, 2015; Flynn, Jones, & Ausderau, 2016; Mizrahi et al., 2012). It is an important stress management technique that has been widely used in various populations including adolescents, athletes, pilots, and patients (e.g., Charalambous et al., 2015; Evans et al., 2004; Flynn et al., 20016; Jing et al., 2011).

Imagery can also have a powerful effect on the responses experienced during acute psychological stress. It can alter the intensity of emotions such as anxiety (Cumming, Olphin, & Law, 2007; Nilsson, Lungh, & Viborg, 2012; Williams, Cumming, & Balanos, 2010; Williams & Cumming, 2012a). Imaging emotional content can also alter cardiovascular activity such as heart rate (Barkay et al., 2012; Cumming et al., 2007; McTeague, Lang, Laplante, & Bradley, 2011; Williams et al. 2010). For example, imaging

nervousness and elevations in heart rate associated with anticipation of competition can elicit feelings of anxiety and increase heart rate and cardiac output even when the competition is not immediately forthcoming (Cumming et al., 2007; Williams et al., 2010).

Although imagery can modify symptoms that are experienced when exposed to acute psychological stress, most of the previous research has focused on using imagery to reduce or diminish feelings of anxiety (e.g., Charalambous et al., 2015; Mizrahi et al., 2012). However, research suggests that instead of aiming to lower symptoms of anxiety, it may be more beneficial to view these symptoms as facilitative (Chamberlain & Hale, 2007; Jones & Swain, 1995; Swain & Jones, 1996). For example, athletes have reported anxiety symptoms perceived as facilitative to have a positive impact on how they approach and perform in a stressful or challenging situation (Chamberlain & Hale, 2007; Jones & Swain, 1995; Swain & Jones, 1996). Similarly in an academic setting, positive perceptions of anxiety symptoms are associated with greater performance in student note taking (Carrier, Higson, Klimoski, & Peterson, 2014). Consequently, the directional perceptions of anxiety (i.e., whether symptoms are perceived as being helpful or hurtful) may be just as important as reducing symptoms for successful coping in stressful situations (Chamberlain & Hale, 2007; Swain & Jones, 1996). The theory of challenge and threat states in athletes (Jones, Meijen, McCarthy, & Sheffield, 2009) and Jones' model of debilitative and facilitative state anxiety propose that more positive perceptions of anxiety are experienced when individuals experience greater levels of confidence and feelings of control (Jones, 1995). Therefore, it may be more appropriate to use imagery to increase feelings of confidence and perceived control rather than using imagery to completely diminish the "stress". For example, helping individuals accept responses to stress (e.g., increases in heart rate and anxiety) as inevitable and view these increases as more facilitative in overcoming a stressful situation.

Research using imagery to alter the appraisal of stress or instilling feelings of confidence and being in control appears successful. Lang's (1979) bioinformational theory proposes that all images are composed of three types of propositions: (a) stimulus propositions (i.e., details of the scenario), (b) response propositions (i.e., responses that would be experienced when exposed to the real-life stimulus), and (c) meaning propositions (i.e., the relationship between the stimulus and response propositions). The inclusion of these propositions is thought to underlie imagery's effectiveness. In support of this theory, Jones, Mace, Bray, MacRae, and Stockbridge (2002) demonstrated that imagery emphasising feelings of confidence and being in control of emotions elicited higher self-efficacy and lower perceived stress of a climbing task. Additionally, when response propositions such as elevations in heart rate and feelings of anxiety are imaged alongside feelings of confidence and being in control (i.e., challenge imagery), individuals perceive the situation to be less threatening and report greater feelings of confidence, and anxiety to be more helpful (Cumming et al., 2007; Williams et al., 2010; Williams & Cumming, 2012a). By contrast, imaging the same responses (i.e., elevations in heart rate and feelings of anxiety) but changing the meaning propositions to not feeling confident or in control (i.e., threat imagery) leads to the task being perceived as more threatening, lower confidence, and similar levels of anxiety to the challenge imagery but perceived as more debilitative (Cumming et al., 2007; Williams et al., 2010; Williams & Cumming, 2012a).

Challenge and threat imagery elicit greater feelings of anxiety and increases in cardiac activity compared with neutral imagery that does not include response propositions associated with stress (Williams et al., 2010). However, the perceptions of these responses following challenge and threat scripts are considerably different. Importantly, Williams et al. (2010) demonstrated that the majority of participants selected the challenge imagery to be the most helpful imagery in dealing with stress compared with the neutral and threat imagery.

This research supports the notion that imagery containing responses to stress, but accompanied by positive interpretations, is likely to elicit the most adaptive coping response when exposed to a stressful situation.

Despite research supporting the effects of challenge and threat imagery, these studies have been limited to either hypothetical stressful situations (Williams et al., 2010) or tasks which may not have been perceived as stressful, thus failing to elicit a stress response (Williams & Cumming, 2012a). While a number of studies have examined cardiovascular responses during emotive imagery, research has yet to examine whether imagery can alter the cardiovascular responses to an actual stress task.

The present study was the first to examine whether imagery designed to alter stress appraisal could manipulate anxiety and heart rate responses in response to a standardized acute psychological stress task. Using a within subject design, the study incorporated measures of heart rate, anxiety (intensity and how helpful or hurtful symptoms were perceived to be), and confidence before and when exposed to three speech preparation tasks. Prior to each speech preparation exposure, participants performed either challenge, threat, or neutral imagery (one imagery condition prior to one speech preparation).

It was hypothesised that challenge imagery would elicit a greater challenge appraisal than threat and neutral imagery, while threat imagery would elicit a greater threat appraisal compared to challenge and neutral imagery. Due to the higher level of perceived threat, it was hypothesised that although all speech preparations would be stressful and elicit increases in heart rate, perceived stress and heart rate would be significantly greater during the threat imagery speech preparation compared to the challenge and neutral imagery speech preparations (Maier, Waldstein, & Synowski, 2003; Teague, Lang, Laplante, & Bradley, 2011). It was also hypothesised that the greatest increases in anxiety would occur following the challenge and threat imagery compared with the neutral imagery (Williams et al., 2010;

Williams & Cumming, 2012a). Finally, it was hypothesised that compared to neutral and challenge imagery, threat imagery would elicit lower confidence and more negative interpretations of anxiety (Williams et al., 2010; Williams & Cumming, 2012a).

Method

Participants

Twenty five healthy females (80% white; M_{age} = 23.24 (*SD* = 4.19); Mean body mass index = 22.95 (*SD* = 3.85)) took part in the study. Participants were non-smokers with no history of chronic disease and had no illness or infection. Participants refrained from vigorous physical activity 24 hours prior, alcohol 12 hours prior, and food and caffeine 2 hours prior to testing. Prior to data collection ethical approval was obtained from the university ethics committee and all participants provided written informed consent.

Heart Rate

The cardiac pulse signal was recorded continuously during the protocol using a pulse oximeter (InVivo 4500 MRI; Invivo Research Corp., Orlando, FL) attached to the ring finger of the right hand. Following automated R-peak detection using a custom algorithm in Spike2 (ver. 6.06; Cambridge Electronic Design Limited, Cambridge, UK), R-peak selection was manually inspected and artefacts were removed where necessary for baseline and speech preparation periods.

Psychological Measures

Cognitive and somatic anxiety and self-confidence. The Immediate Anxiety Measures Scale (IAMS; Thomas, Hanton, & Jones, 2002) assessed the intensity and directional perception (i.e., interpretation) of cognitive anxiety, somatic anxiety, and self-confidence. Intensity is first assessed by participants rating the extent they are experiencing each construct on a 7-point scale from 1 (*not at all*) to 7 (*extremely*). The interpretation of whether these symptoms are helpful or hurtful to the situation is then rated on a 7-point scale

ranging from -3 *(very debilitative/negative)* to +3 *(very facilitative/positive)*. Prior to completing the questionnaire individuals are provided with definitions of each construct to ensure they fully understand the meaning of each one. The IAMS is a valid and reliable measure to assess state cognitive and somatic anxiety and self-confidence (Thomas et al., 2002) and has been used in previous imagery and stress research (e.g., Williams et al., 2010; Williams et al., 2016).

Perceived challenge-threat states. Similar to previous research (Turner, Jones, Sheffield, Barker, & Coffee, 2014; Turner, Jones, Sheffield, & Cross, 2012) a single item was employed to assess the extent to which participants perceived speech preparation tasks to be perceived as challenging or threatening. Responses were made on a 7-point scale from 1 *(completely threatening and not at all challenging)* to 7 *(completely challenging and not at all threatening)*.

Stressfulness of tasks. Following each speech preparation task participants indicated how stressful they perceived the task to be. Responses were made on a 7-point scale ranging from 1 (*not at all stressful*) to 7 (*extremely stressful*).

Imagery evaluation. To ensure that participants were able to image the scenarios as described, participants completed four items used previous in imagery research (Williams & Cumming, 2012a). The first item asked participants the extent to which they imaged each scenario as instructed. Responses were made on a 7-point scale from 1 (*not at all as instructed*) to 7 (*completely as instructed*). The remaining three items asked participants to indicate the ease with which they were able to image each of the three imagery scenarios. Responses were made on a 7-point scale ranging from 1 (*very hard to image*) to 7 (*very easy to image*).

Speech Preparation Tasks

The speech preparation task consisted of the 2 min preparation phase from the public speaking task used in previous research (Bosch et al., 2009; Wager et al., 2009a, 2009b). In each of the three preparation tasks participants were informed that they had been falsely accused of one of the following; (a) shoplifting a belt, (b) cheating in an exam, and (c) not purchasing a rail ticket. The speech topics were developed after focus groups with undergraduate students from the same university to deem stressful situations where they would be accused of something. Participants were told that they had 2 min to prepare a 4 min speech in which they were to defend themselves to either the store manager, exams officer, or station manager (depending on the speech preparation topic). The preparation phase of the speech task has been shown to increase anxiety, cardiovascular, and neural responses to stress (Wager et al., 2009a; 2009b; Roemmich et al., 2011; Llabre et al., 1998). Participants were informed that following the speech preparations, they would be asked to give one of the three speeches in front of the experimenter and a video camera. The speech topic for the actual delivery was randomly selected by the experimenter. During the delivery, participants were instructed that they must keep talking for the entire 4 min of the speech and two senior academics would analyse and mark the recorded video.

Imagery

Imagery scripts were designed for the present study based on those previous employed to manipulate challenge and threat appraisal of situations (Williams et al., 2010; Williams & Cumming, 2012a) and are included in the appendix. In line with the recommendations of Lang's (1979) bioinformational theory, scripts included stimulus, response, and meaning propositions. Both the challenge and threat scripts were matched on stimulus (e.g., *"*the store manager arrives*"*) and responses (e.g., *"*your heart is pounding*"*) propositions. However, the meaning of these responses was altered so that compared to the threat condition (e.g., *"*This is your body preparing to perform the speech poorly*"*),

individuals in the challenge condition would feel confident and that they were able to cope (e.g., *"*This is your body preparing to perform the speech well*"*). This alteration was done through manipulating feelings of efficacy and control over the situation (Jones et al., 2009; Williams et al., 2010). A neutral script for control purposes did not include any reference to responses to stress and simply described the series of events (i.e., stimulus propositions).

To prevent differences in responses being a result of the speech preparation topics (i.e., shoplifting, exam cheating, rail ticket stealing) rather than the imagery condition (i.e., challenge, threat, neural), three imagery scripts were created for each speech preparation topic (i.e., there was a challenge shoplifting script, a threat shoplifting script, and a neutral shoplifting script). Consequently, nine scripts were produced in total and participants were randomly assigned to different scripts so that each participant experienced three conditions (i.e., challenge, threat, and neural script), as well as three scenario scripts (i.e., shoplifting, exam cheating, and rail ticket script). For example, one participant may have had a challenge shoplifting script, a neutral train ticket script, and a threat exam cheating script whereas another participant may have had a challenge train ticket script, a neutral exam cheating script, and a threat shoplifting script.

Pilot testing revealed that participants preferred the imagery content to be broken down into four parts. This allowed the participants to take in all the imagery information more effectively. Participants were provided with a specific part of the script and given 30 s to read and image the content described. Each imagery condition lasted for precisely 2 min.

Procedures

The study was conducted over two laboratory sessions lasting approximately 2 hours in a research lab where the first author is based. All sessions were one-to-one and face-to-face with an imagery trained researcher. Participants were provided with an overview of the protocol and height and weight were recorded to calculate BMI. Next, participants were

provided with layered stimulus response training (for more details see Cumming et al., 2016) to make their imagery as clear and vivid as possible. Participants were then provided with an imagery exercise to practice reading instructions and then imaging the subsequent content to become accustomed to the format of the imagery scripts.

Prior to the stress portion of the protocol, participants completed the IAMS to indicate how anxious and confident they felt prior to any exposure of the stress tasks (pre-trial anxiety assessment). They were then positioned in a comfortable position and heart rate equipment was attached. Once this setup had been done (~10 min), participants completed a 6 min adaptation period. Next, participants completed the first speech preparation trial. Each trial started with a 2 min resting baseline during which heart rate was continuously recorded. After baseline, participants received the 2 min imagery script, which contained both the task instructions and imagery manipulation. Following the imagery, participants completed the IAMS and challenge threat appraisal measure. Next, participants completed the 2 min speech preparation task during which heart rate was continuously recorded. Following the speech preparation task, the trial ended with participants indicating how stressful they found the preparation task.

The procedures for the speech preparation trial were then repeated another two times so that three trials were completed in total. Due to the number of scripts, counterbalancing the order completely was not possible due to the number of possible orders. Consequently, because the study's main interest was in the challenge and threat comparison, the neutral script was always delivered in the second trial. The challenge and threat scripts were then counterbalanced so that half of the participants experienced the threat script first and the other half experienced the challenge script first. This counterbalancing was to account for any effects of repeated stress task exposure. Following the three speech preparation trials, participants completed the imagery evaluation. Finally, participants delivered one of the 4

min speeches they had planned which was decided at random by the researcher picking one of the speech topics out of a hat. Participants were then thanked for their participation.

Data Reduction and Analysis

Heart rate data was analysed continuously during the 2 min of each baseline and during the 2 min of each speech preparation phase. Averages were calculated for the 2 min of each baseline, and the 2 min of each speech preparation. First, compliancy with the protocol was examined by investigating the extent to which participants imaged as instructed. One participant reported not imaging as instructed and was thus excluded from the analysis leaving a total sample of 24 participants. Of these remaining participants, 12 completed the challenge condition first and the threat condition last and the other 12 completed the threat condition first and challenge condition last.

To examine whether the content of the speech preparation tasks (i.e., shoplifting, exam cheating, not purchasing a rail ticket) influenced the psychological and cardiovascular responses to stress, a 2 Time (baseline, speech preparation) × 3 Speech topic scenario (shoplifting, exam cheating, train ticket stealing) analysis of variance (ANOVA) examined whether there were any differences in heart rate, and a 3 Speech topic scenario (shoplifting, exam cheating, train ticket stealing) one-way repeated measures ANOVA examined whether there were any differences in task stressfulness. Two separate one-way repeated measures ANOVAs were run to examine any differences in speech task topic imaged (i.e., shoplifting, exam cheating, not purchasing a rail ticket) and the imagery condition (i.e., challenge, neutral, threat).

Next, analyses were conducted to examine the extent to which the imagery conditions (i.e., challenge, neutral, threat) altered the psychological and heart rate responses to stress. First, two separate 3 Imagery condition (challenge, neutral, threat) one-way repeated measures ANOVAs examined any differences in how stressful the speech preparation was

perceived to be and the extent to which it was appraised as a challenge or threat. Heart rate was analysed using a 2 Time (baseline, speech preparation) × 3 Imagery condition (challenge, neutral, threat) to examine whether the speech preparation phases significantly perturbed heart rate, and whether perturbations were different following the different imagery conditions. Separate 4 Time (pre-trial, challenge, neutral, threat) repeated measures ANOVAs examined any differences in anxiety and confidence between the time point prior to any of the speech preparation trials (pre-trial) and the moments immediately prior to the speech preparations (following the imagery manipulations). Pairwise least significant differences comparisons were used to follow up on all significant main effects and interactions.

Data was screened for any missing values. There was no missing data for heart rate responses, but due to technical errors in recording of psychological responses there were missing cases for ease of imaging (n = 2), task stressfulness (n = 3), challenge threat (n = 3), somatic anxiety intensity (n = 1), somatic anxiety direction (n = 2), and confidence (n = 1). Little's MCAR test (Little & Rubin, 1987) confirmed this data was missing completely at random $\chi^2(112) = 124.69$, $p = .194$. However, participants were excluded from any analysis in which they had missing data.

Results

Speech Task Topics

Means and standard deviations of the heart rate and perceived stressfulness broken down across speech topic are presented in Table 1 with a similar baseline heart rate in each topic trial. A 2 Time (baseline, speech preparation) × 3 Speech topic (shoplifting, exam cheating, train ticket stealing) ANOVA examining heart rate activity revealed a significant main effect for time, $F(1, 21) = 59.68$, $p < .001$, $\eta_p^2 = .740$, but no significant main effect for speech topic ($p = .622$) and no time × speech topic interaction ($p = .555$). Participants

experienced a significant increase in heart rate from baseline to speech preparation for all three speech preparation tasks irrespective of speech topic. The one-way repeated measures ANOVA revealed no significant differences in the perceived stressfulness of the speech preparation tasks due to the speech topic ($p = .695$).

Ease of Imaging

Ease of imaging the different speech preparation conditions broken down by speech task topic and imagery manipulation are displayed in Table 2. Results revealed no significant differences in ease of imaging the different speech preparation topics (i.e., shoplifting, exam cheating, train ticket), $F(2, 40) = 1.19$, $p = .314$, $\eta_p^2 = .056$, or the different imagery conditions (i.e., challenge, neutral, threat), $F(2, 40) = 1.95$, $p = .155$, $\eta_p^2 = .089$.

Task Stressfulness

Stressfulness ratings for the speech preparation task broken down across imagery conditions are reported in Table 3. The 3 Imagery condition (challenge, neutral, threat) ANOVA revealed a significant main effect for imagery condition, $F(2, 40) = 5.30$, $p = .009$, $\eta_p^2 = .209$. Participants reported the speech preparation task to be significantly more stressful following the threat imagery compared to the challenge and neutral imagery.

Perceived Challenge Threat State

Challenge threat ratings for the speech preparation tasks are presented in Table 3. The 3 Imagery condition (challenge, neutral, threat) ANOVA revealed a significant main effect for condition on challenge threat appraisal, $F(2, 40) = 12.08$, $p < .001$, $\eta_p^2 = .377$, in which the speech preparation task following the threat imagery was perceived to be significantly more threatening than the speech preparation tasks following the challenge and neutral scripts. There were no differences in speech preparation task appraisal between the challenge and neutral conditions.

Heart Rate

The 2 Time (baseline, speech preparation) × 3 Imagery condition (challenge, neutral, threat) ANOVA indicated a significant main effect for time, $F(1, 23) = 44.30$, $p < .001$, $\eta_p^2 = .658$, condition $F(2, 37) = 4.39$, $p = .027$, $\eta_p^2 = .160$, and a significant time × condition interaction, $F(1, 31) = 4.14$, $p = .040$, $\eta_p^2 = .152$. Posthoc analysis indicated that there were no differences at baseline between the conditions, and while all three speech preparations perturbed cardiac activity, heart rate was significantly greater during the speech preparation following the threat imagery, compared to the speech preparations following the neutral and challenge imagery conditions. This has been depicted in Figure 1 as a change score of speech preparation minus baseline for each condition.

Anxiety and Confidence

Cognitive and somatic anxiety intensity and directional interpretation, and self-confidence means and standard deviations are reported in Table 3.

Anxiety intensity. Two separate 4 Time (pre-task, challenge, neutral, threat) ANOVAs revealed significant differences in cognitive, $F(3, 66) = 19.72$, $p < .001$, $\eta_p^2 = .473$, and somatic, $F(3, 63) = 22.48$, $p < .001$, $\eta_p^2 = .517$, anxiety intensity. Post hoc analyses indicated that following all three imagery conditions participants felt significantly more cognitively and somatically anxious compared to the pre-imagery assessment. There were no differences between any of the imagery conditions in cognitive or somatic anxiety intensity levels.

Anxiety symptom interpretation. Two 4 Time (pre-task, challenge, neutral, threat) ANOVAs revealed significant differences in cognitive, $F(3, 66) = 5.10$, $p = .003$, $\eta_p^2 = .188$, and somatic, $F(3, 60) = 8.83$, $p < .001$, $\eta_p^2 = .306$, anxiety interpretation. Participants perceived their cognitive anxiety to be significantly more facilitative during the challenge and

neutral conditions compared to pre-tasks assessment. Furthermore, cognitive anxiety during the neutral condition was significantly more facilitative than the threat condition. For somatic anxiety participants perceived their symptoms to be significantly more facilitative during the challenge and neutral speech preparation conditions compared to the pre-tasks assessment and the threat condition.

Self-confidence. The 4 Time (pre-task, challenge, neutral, threat) ANOVA revealed a significant difference in confidence $F(3, 63) = 7.01$, $p < .001$, $\eta_p^2 = .250$. During the challenge and neutral speech task preparations participants felt significantly more confident compared with the threat condition.

Discussion

This study was the first to demonstrate that imagery altering the meaning propositions of the responses to stress can alter how individuals appraise and respond to a stressful situation. Following the threat script, participants perceived the speech preparation task to be significantly more stressful and threatening than the speech preparations following the challenge and neutral imagery. Building on existing literature demonstrating that changing image meaning propositions can alter the appraisal of hypothetical stressful situations (Williams et al., 2010), the present study extends this to an actual stress evoking situation. It appears that this appraisal, in turn, alters confidence as well as the anxiety and heart rate responses experienced in response to the stress task.

In line with previous findings, greater levels of confidence were associated with a challenge appraisal (Jones et al., 2009; Williams et al., 2010). However, results regarding anxiety intensity were different to those previously observed. Anxiety increased in anticipation of the three speech preparation tasks, but there were no differences in cognitive or somatic anxiety intensity between the different speech preparation conditions. Previous research has demonstrated challenge and threat imagery to elicit greater cognitive and

somatic anxiety compared with neutral imagery, and for threat imagery to elicit greater cognitive anxiety than challenge imagery (Williams et al., 2010). Discrepancies between the previous study and the present study could be due to using an actual stress evoking scenario in the present study rather than a hypothetical scenario used previously further supporting the notion that the present study employs a more rigorous design as it is more reflective of day to day life. This suggestion is supported by other research demonstrating similarities in cognitive and somatic anxiety intensity following challenge and threat imagery scripts in relation to an actual task (Williams & Cumming, 2012a). As such, the challenge and threat imagery scripts may not be able to alter anxiety intensity beyond that already being experienced as a result of speech preparation task exposure.

Despite similarities in anxiety intensity, challenge and neutral imagery elicited more facilitative interpretations of anxiety symptoms. This finding supports theories and research suggesting that high levels of anxiety can be perceived as being facilitative towards performance (Jones, 1995; Jones et al., 2009). In support of our hypothesis and previous challenge and threat imagery research (Williams et al., 2010; Williams & Cumming, 2012a), somatic anxiety symptoms were perceived to be significantly more facilitative towards the speech preparation following the challenge imagery compared with the threat imagery. Despite challenge and threat imagery conditions containing similar response propositions and eliciting similar somatic anxiety intensity, imagery that focused on feeling efficacious and in control lead to these symptoms being perceived as more facilitative. Contrary to our hypothesis and previous research (Williams et al., 2010; Williams & Cumming, 2012a), the challenge imagery did not elicit more facilitative perceptions of cognitive anxiety compared to threat imagery. Some studies demonstrating more positive cognitive anxiety direction in a challenge appraisal condition have been accompanied by lower levels of cognitive anxiety intensity (Hale & Whitehouse, 1998; Williams et al., 2010). Consequently, for the speech

tasks in the present study, the similar levels of cognitive anxiety may have been perceived to be similarly facilitative or debilitative irrespective of the imagery condition.

Of particular interest is the increase in heart rate during the speech preparation task following the threat imagery condition. Emotive images and those laden with response propositions can elicit changes in physiological activity (e.g., increases or reductions in heart rate) during the imagery (Barkay et al., 2012; Cumming et al., 2007; Teague et al., 2011; Williams et al., 2010). The present study extends these findings and demonstrates that imagery can also influence the magnitude of the physiological responses experienced during acute psychological stress. Previous research demonstrates that pre-stress instructions encouraging participants to view physiological sensations as adaptive and functional can lead to more adaptive cardiovascular responses of a stress task (Jamieson et al., 2011). The present study demonstrates that imagery can also influence the magnitude of the actual cardiovascular response. Specifically, imaging having control over responses to stress that may typically be perceived as negative and imaging these as being facilitative can elicit a lower heart rate response to stress compared to when these responses experienced are perceived as debilitative.

Interestingly, the challenge and neutral scripts elicited similar psychological and cardiac responses to stress. This finding is somewhat surprising given that the challenge imagery script included response propositions associated with elevated feelings of anxiety in addition to meaning propositions attempting to bolster feelings of confidence and control. It is also contrary to previous research which has demonstrated challenge imagery to elicit greater feelings of confidence and anxiety, as well as greater heart rate during the imagery compared with the neutral condition (Williams et al., 2010). It is possible that the challenge imagery propositions counteracted each other. The inclusion of stress response propositions may have elevated stressfulness, anxiety, and feelings of threat whilst lowering confidence

and facilitative interpretations of anxiety. By contrast, the meaning propositions emphasising feelings of confidence and being in control may have increased confidence and facilitative interpretations of anxiety, whilst lowering anxiety, stressfulness, and threat ratings. This working in opposition would result in similar psychological and heart rate responses to those elicited in the neutral script with the absence of response and meaning propositions.

Imagery's ability to manipulate heart rate and anxiety responses to stress has large implications for both research and applied practice. The use of imagery has been identified as an effective strategy in clinical settings (Holmes & Matthews, 2010). However, while numerous studies have examined the effectiveness of imagery as a relaxation method for a variety of treatments (e.g., Charalambous et al., 2015; Mizrahi et al., 2012), the present findings suggest imagery has the ability to alter views of anxiety in response to acute psychological stress. This finding has large health implications given that negative perceptions of stress are associated with health and mortality (Keller et al., 2012).

Response propositions are thought to be important when using imagery as a therapeutic tool. Lang (1979) proposed that when an individual incorporates response propositions into an image, he/she experiences an actual physiological response (Lang et al., 1980). This occurrence is believed to be the method through which behavior can be modified (Lang, 1979). The present findings suggest that incorporating these response propositions into guided imagery should be done alongside feelings of confidence and being in control to ensure individuals do not experience greater elevations in heart rate or more negative interpretations of responses to stress which can be detrimental to health and well-being (Chida, & Steptoe; Sarason & Sarason, 1984). Further research is needed to examine the role of using imagery to alter views of anxiety in clinical populations (e.g., PTSD, generalized anxiety disorder).

A limitation of the present study is that the number of imagery conditions and speech task topics meant that the 36 counterbalance orders made us unable to completely counterbalance. However, the threat and challenge conditions were counterbalanced because the comparison between these conditions was of the greatest interest to the present study. The neutral imagery being the middle condition may have been why challenge imagery did not differ from neutral imagery. Despite this, the challenge and threat imagery conditions were counterbalanced and elicited differences in cardiovascular and psychological responses to the stress task. A second limitation was the female only sample. Research has suggested that females can display higher levels of anxiety, lower confidence, and different cardiovascular responses to acute psychological stress compared to male counterparts (Feingold, 1994; Veldhuijzen van Zanten et al., 2004). However, previous imagery and stress research suggests males and females do not respond differently to challenge and threat imagery manipulations (Williams et al., 2010). Despite this, future research should see whether the findings of the present study generalise to males. A notable strength of the study is that there were no differences in stressfulness or ease of imaging the different speech topics (i.e., shoplifting, exam cheating, rail ticket non purchase), or ease of imaging the different imagery conditions (i.e., challenge, neutral, threat). This is important given that stressfulness and imagery ability are associated with cardiovascular activity and anxiety (Callister, Suwarno, & Seals, 1992; Campbell & Ehlert, 2012; Lang, Kozak, Miller, Levin, & McLean, 1980; Williams & Cumming, 2015). Consequently, it is probable that differences in the psychophysiological responses across the speech conditions were due to the manipulated meaning propositions in the imagery scripts.

While the present findings are insightful, it is important future research investigates individual and situational factors likely to influence imagery's effectiveness in regulating responses to stress. Situational factors could include things such as the nature of the stress. It

would also be interesting to examine the effectiveness of the imagery on the delivery of the different speech topics. Findings of the present study demonstrate that challenge imagery elicited similar responses to neutral imagery. This may be due to the nature of the speech task and elevated response propositions not always being perceived to be helpful. Additionally, imagery ability is likely to influence the effectiveness of stress regulating imagery. Better imagers tend to experience greater benefits from imagery use than lower level counterparts (Robin et al., 2007), and imagery ability is related to factors such as confidence, anxiety, and challenge and threat appraisal (Williams & Cumming, 2012b; Williams & Cumming, 2015). Consequently, future research should investigate whether imagery ability is able to influence imagery's effectiveness in altering the psychological and cardiovascular responses to stress.

In conclusion, findings from the present study demonstrate that by altering the meaning propositions of an imagery script, imagery can alter both the cardiovascular and psychological responses experienced when exposed to acute psychological stress. Imagery, which acknowledges the stressful nature of a task, but emphasises feelings of efficacy and control (i.e., challenge imagery) can lead to more positive interpretations of anxiety and lower cardiovascular activity resulting from the stress task compared with imagery containing that same acknowledgement of the stress task but without feeling confident/efficacious or in control (i.e., threat imagery). Challenge imagery could therefore prove to be an effective intervention technique in the regulation of adaptive coping to stressful experiences.

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Table 1.

Mean (standard deviation) heart rate and stressfulness ratings broken down across the different speech preparation topics

	Shoplifting	Exam cheating	Train ticket
HR baseline (i.e., prior to task)	69.03 (9.44)	69.75 (8.98)	69.88 (8.37)
HR speech preparation	71.66* (9.45)	71.62* (9.96)	72.28* (9.88)
Perceived stressfulness	4.76 (1.45)	4.67 (1.56)	4.43 (1.33)

Note. HR = heart rate (beats per minute), stressfulness ratings ranged from 1 (not at all stressful) to 7 (extremely stressful). * significantly greater than baseline ($p < .001$). No significant differences across topics.

Table 2.

Mean (standard deviation) ease of imaging across the different speech content, and ease of imaging across the different imagery conditions.

	Speech content			Imagery conditions		
	Shoplifting	Exam cheating	Train ticket purchase	Challenge	Neutral	Threat
Ease of imaging	3.76 (1.64)	4.33 (1.83)	4.24 (1.67)	3.76 (1.87)	4.52 (1.40)	4.05 (1.80)

Note. Ease of imaging ratings ranged from 1 (very hard to image) to 7 (very easy to image). No significant differences across speech topics or imagery conditions.

Table 3.

Mean (standard deviation) ratings for task stressfulness, challenge threat appraisal, anxiety, and confidence across imagery conditions.

	Pre-stress Trial	Challenge Condition	Neutral Condition	Threat Condition
Task Stressfulness (1 = not at all, 7 = extremely)	-	4.19 [a]* (1.25)	4.38 [a]** (1.28)	5.29 (1.55)
Challenge-Threat (1 = completely threatening, 7 = completely challenging)	-	5.43 [a]** (1.25)	5.38 [a]** (1.40)	4.24 (1.38)
Cognitive Anxiety Intensity (1 = not at all, 7 = extremely)	2.78 (1.00)	4.83 [b]*** (1.64)	4.83 [b]*** (1.30)	5.30[b]*** (1.36)
Somatic Anxiety Intensity (1 = not at all, 7 = extremely)	2.18 (0.96)	4.09 [b]*** (1.34)	4.23 [b]*** (1.23)	4.77[b]*** (1.31)
Cognitive Anxiety Direction (-3 = very debilitative, +3 = very facilitative)	-0.30 (1.49)	0.61 [b]* (1.70)	1.13 [a,b]** (1.63)	-0.04 (1.46)
Somatic Anxiety Direction (-3 = very debilitative, +3 = very facilitative)	-0.43 (1.57)	0.81[a,b]** (1.57)	1.05[a,b]** (1.36)	-0.29 (1.55)
Confidence (1 = not at all, 7 = extremely)	4.23 (0.87)	5.00[a]* (1.20)	4.95[a]* (1.33)	3.86 (1.08)

Note, [a] significantly different from the threat condition, [b] significantly different from the pre-trial assessment, * $p < .05$, ** $p < .01$, *** $p < .001$.

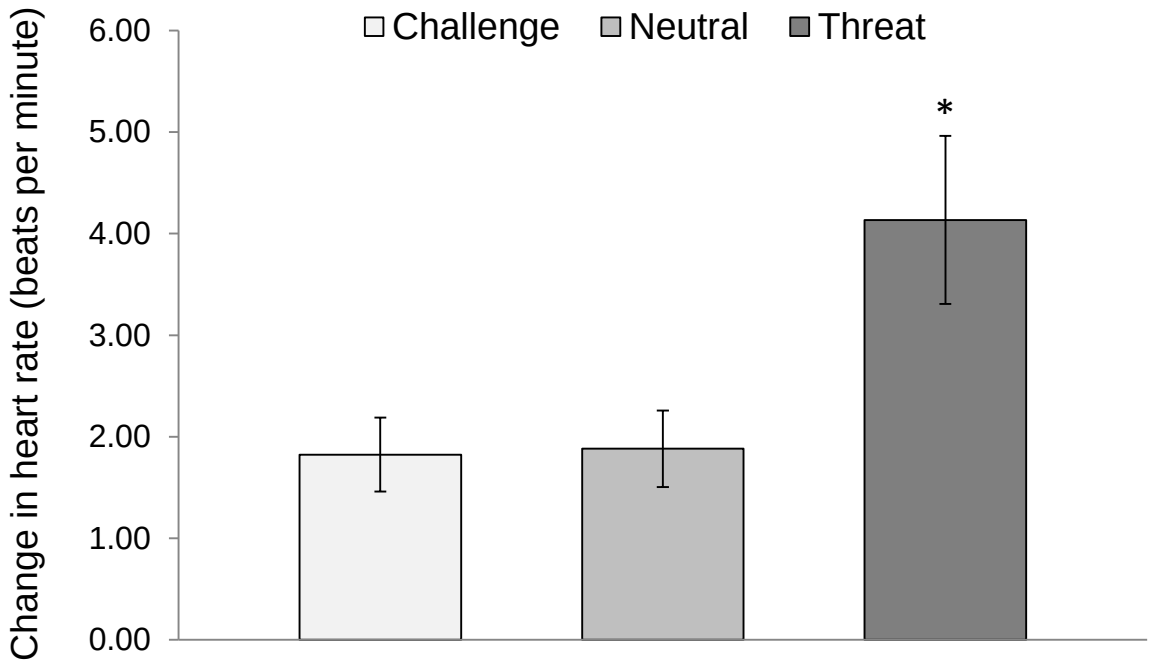

Figure 1. Mean (SE) change in heart rate from the resting baselines to speech preparation phases following the challenge, neutral, and threat imagery. Note: significant time effect ($p < .001$), * significant interaction with greater increase from baseline to speech preparation in the threat imagery condition compared to the challenge and neutral imagery condition ($p < .05$).