Anxiety and motor performance: More evidence for the effectiveness of holistic process goals as a solution to the process goal paradox

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Abstract

Objectives. Recent research has reported the benefits of using holistic rather than part process goals to avoid the negative effects associated with the conscious processing of task relevant information by skilled but anxious athletes. This experiment compared the efficacy of these two goal focus strategies in a neutral condition and a competitive condition in which cognitive state anxiety was elevated.

Design. Laboratory-based experimental design using a mixed model with between (process goal groups) and within-subjects (neutral and competitive) conditions.

Method. Thirty male and female undergraduate students aged between 19 and 44 years of age completed 896 practice repetitions of a race car driving simulation using discovery learning. Participants were then placed in either a holistic or part process goal group using stratified random assignment. The practice phase was followed by neutral and competitive conditions, during which driving performance and psychophysiological measures were collected.

Results. Analysis of variance of lap times and driving errors revealed that the holistic process goal group outperformed the part process goal group in the competition condition. Analysis of psychophysiological measures suggested that the performance of both process goal groups in the competitive condition was associated with the investment of compensatory effort.

Conclusions. Compared to part process goals, holistic process goals confer performance benefits for skilled athletes who perform under competitive pressure.

Keywords: Anxiety, attention, goal setting, heart rate variability, psychophysiology

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For elite athletes, competition can result in increased performance anxiety; yet the mechanisms through which anxiety exerts its influence upon performance remain elusive. One popular approach to explaining anxiety effects on performance has focused on the disruptive influence of self-focus on motor skills performed in stressful situations (Baumeister, 1984). Several self-focus theories have received support, including Masters' (1992) conscious processing hypothesis (CPH) and Beilock and Carr's (2001) explicit monitoring hypothesis. Of these, the CPH has received the most attention in the sport psychology literature. Masters hypothesized that highly skilled but anxious individuals might attempt to ensure task success by adopting a mode of conscious control primarily associated with the early stages of learning. This conscious control is based upon explicit knowledge, which is accessed in a step-by-step manner, resulting in movements directed by sequences of small, independent movement units. The slow and effortful performance produced by this conscious control creates opportunity for error at each transition between the independent movement units (Wilson, Smith, & Holmes, 2007). This performance is in contrast with the typical automatic functioning of the expert, which is based upon movement sequences in which the smaller, independent movement units of the novice have been "chunked" into larger units in which movements are represented more holistically, resulting in performance that is more efficient, fluid and less effortful (Shiffrin & Schneider, 1977).

Despite the accruing support for the CPH, several authors have noted that the performance deficits credited to conscious processing effects could also be caused by a competing attentional explanation (Mullen, Hardy, & Tattersall, 2005; Wilson, Chattington, Marple-Horvat, & Smith, 2007). Several studies have examined the competing conscious processing and attentional explanations but these have produced a mixed pattern of findings,

with support for conscious processing (Gucciardi & Dimmock, 2008), attentional effects (Mullen et al., 2005; Wilson, Chattington et al., 2007), and more equivocal results (Mullen & Hardy, 2000). According to Mullen et al. (2005), these discrepant findings can be explained by the view that anxiety-related performance decrements might be caused by both attentional and conscious processing effects, in line with Eysenck's (1988) suggestion that anxiety-related performance failure might be attributable to multiple causes. Consequently, from a conscious processing perspective, Mullen and Hardy (2010) claimed that it is important to establish whether skilled but anxious performers' use of explicit knowledge *does* invoke lapses into conscious processing. In order to do so, Mullen and Hardy suggested that researchers needed to design studies that isolate conscious processing effects without invoking alternative attentional explanations, proposing that one way of so doing was to examine the effect of different types of process goals upon the performance of anxious individuals.

First proposed by Hardy and Nelson (1988), process goals specify the behaviours, skills and strategies that are essential for effective task execution (Kingston & Hardy, 1997); for example, a golfer might focus on a relaxed grip of the club while putting. Sport psychologists have recommended process goals as a means of helping skilled performers deal with high anxiety by providing them with a means of focusing their attention on important aspects of performance (Hardy, Jones, & Gould, 1996; Kingston & Hardy, 1997). By their very nature, process goals encourage performers to focus on specific aspects of a task using explicit knowledge about the task, thus creating something of a paradox (Mullen & Hardy, 2010). The paradox arises as Masters' CPH predicts that a focus on *part* of a movement using a process goal underpinned by explicit knowledge will disrupt the normal automatic task processing of experts, leading to lapses into conscious processing. A number of researchers (e.g., Hardy, Mullen, & Jones, 1996; Kingston & Hardy, 1997) have suggested that process

goals that are more holistic in nature might avoid the potential interference explicit in Masters' hypothesis. Holistic process goals are goals that focus on a single conceptual cue to encapsulate a movement in its entirety; for example, a skilled golfer might use "smooth" or "tempo" as a holistic cue to help trigger the larger movement units associated with automatic processing of the expert performer. These holistic process goals may function by encouraging "chunking" of the movement, in which the individual elements of a task are incorporated into a single representation, promoting smoother performance (Neves & Anderson, 1981). Thus, a holistic process goal should not induce conscious processing as conscious control can only be exerted over parts of a movement. In contrast, part process goals should cause lapses into conscious processing as using explicit knowledge to focus on a movement should encourage the use of smaller, more independent movement units. Differentiating between these two types of goal avoids the problem of invoking attentional explanations of anxiety effects, as although the cues activate different movement units, both types of goal are not expected to consume differential attentional resources. Thus, any performance impairment associated with the use of a part process goal is more likely due to the effect of conscious processing.

Although researchers have begun to examine the utility of process goals (Gucciardi & Dimmock, 2008; Jackson & Willson, 1999; Jackson, Ashford, & Norsworthy, 2006; Kingston & Hardy, 1997), the findings from these studies are somewhat inconsistent. Mullen and Hardy (2010) claimed that the mixed results do little to clarify the part process goal paradox. Consequently, in three experiments they directly compared the effectiveness of part and holistically focused process goals, predicting that skilled but anxious performers who used holistic process goals would outperform those who used part process goals, and in line with the CPH, that performers who used part process goals would experience performance impairment in a high anxiety condition. The three experiments utilized several different motor tasks; golf putting, long jumping, and basketball free throws, which participants

performed using either a part or holistic process goal in both low and high anxiety conditions. The results were consistent across all three experiments; a single holistic process goal helped maintain or improve performance in the high anxiety condition. The prediction that part process goals would disrupt task execution under pressure was less clear as performance did not significantly deteriorate from baseline, low anxiety levels, but was significantly lower than that recorded by participants who used a holistic process goal in all three experiments. Based on the evidence that participants who used a part process goal did not experience the same performance benefits as those who used a holistic process goal in the competitive condition, Mullen and Hardy argued that this relative impairment was evidence that conscious processing was activated.

One limitation of the studies conducted by Mullen and Hardy (2010) was their failure to include some of the psychophysiological indices used in other studies examining the CPH. For example, Mullen et al. (2005) proposed heart rate variability (HRV), estimated by spectral analysis of the cardiac signal, as a measure of the intensity of attentional processing associated with the shifts from automatic to controlled processing predicted by the CPH. Mullen and Hardy's findings would have been strengthened by the inclusion of such a measure in order to provide some additional insight into the psychophysiological activation states underpinning conscious processing effects.

Heart rate variability is typically examined by spectral decomposition of the heart rate signal, which produces periodic components of HRV aggregated within three main frequency bands, each of which is associated with different functional influences in the modulation of heart rate. Of these three bands, spectral power in the low-frequency band (LF; .07 - .14 Hz) has consistently decreased, reflecting an increase in effort (Mulder, 1992), to a range of manipulations that cause major changes in task structure and induce different modes of operation, as in the shift from automatic to controlled processing (Mulder, 1992; Veltman,

2002). While HRV has not been used to examine the cardiac activation states underpinning the use of holistic and part process goals, it has been used in research examining conscious processing effects. Mullen et al. (2005) found no effects of anxiety upon HRVLF in their study that examined whether conscious processing or attentional explanations could best account for anxiety effects upon the skill of golf putting. While there were no effects of anxiety on HRVLF, anxiety-related performance impairment was associated with changes in the HRV high frequency band, which the authors suggested might be related to changes in breathing-based relaxation strategies. Also using a golf-putting task, Wilson, Smith et al. (2007) also found that anxiety had no effect upon HRVLF but did report that self-reported mental effort was sensitive to anxiety effects. Taken together, these HRV results are inconclusive, although direct comparisons are complicated by the different ways in which cardiac data were collected, pre-processed and analyzed. Evidently, more research is required to establish how anxiety and attentional manipulations interact to affect the cardiac activation states that underpin motor performance.

Part of the problem in using HRV to examine changes in mental effort related to increased anxiety lies in the physiological origins of fluctuations in the LF band of the HRV power spectrum, which are thought to be reflective of both sympathetic and vagal activity (Berntson et al., 1997). Mullen et al. (2005) suggested that in their study the hypothesized effort-related reductions[1] in the HRVLF band might have been masked by the impact of physiological responses to increased cognitive anxiety. Specifically, the sympathetic response to increased state anxiety may have “flooded” the LF band, resulting in large increases in spectral power from baseline, and in so doing, obscured the impact of mental effort in this band. Measures of sympathetic activity would help examine this suggestion. Typically,

[1]Reductions in HRVLF power from baseline conditions are representative of *increased* effort

sympathetic activity is measured using impedance cardiography of the cardiac pre-ejection period (Sherwood, Allen, Obrist, & Langer, 1986), or plasma-borne catecholamine response (Nater et al., 2006). Unfortunately, both these measures are fairly invasive and the procedures themselves might lead to increases in state anxiety, confounding the effects of experimental manipulations. As such, a non-invasive marker of sympathetic activity would be preferable. Salivary alpha amylase (sAA) has emerged as a promising candidate to index stress-induced activity of the sympathetic nervous system (Bosch, de Geus, Veerman, Hoogstraten, & Nieuw Amerongen, 2003; Chatterton, Vogelsong, Lu, Ellman, & Hudgens, 1996). Filaire, Portier, Massart, Ramat and Teixeira (2010) used both HRV and sAA to examine autonomic nervous system activation in a sample of college professors lecturing to 200 students, predicting that the lecture would increase ‘mental stress’. Filaire et al. reported that increases in state anxiety were indeed accompanied by a tilting of autonomic balance toward sympathetic activation as sAA increased and HRVHF decreased in response to the stressor.

The present study set out to extend previous research by employing both HRV and sAA to explore the psychophysiological activity of skilled but anxious participants who used part and holistic process goals. Examination of HRV could provide some support for the suggestion that holistic process goals encourage more efficient automatic processing, while part process goals are associated with more effortful controlled processing. Using a part process goal should result in greater reductions in LF spectral power from baseline relative to those associated with holistic process goal use, reflecting the extra mental effort associated with controlled processing. We measured inter beat intervals and saliva in resting baseline, task baseline, and competitive conditions. In the competitive condition, we predicted that cognitive state anxiety and sAA would increase across both groups and that a holistic process goal would enable participants to maintain levels of performance, HRVLF power and self-reported effort close to those observed in the task baseline condition, while a part process

goal would be associated with impairment of performance and increased mental effort, as indexed by greater self-reported effort and reductions in HRVLF power.

Method

Participants

Thirty male and female students were recruited from a British university to take part in the study. All participants had held a full UK driving licence for at least one year, and had no experience of race driving video games. Participants were randomly assigned to either a holistic process goal or part process goal condition, stratified by sex. Both groups consisted of 5 females and 10 males. Participants in the holistic process goal group were between 19 and 44 years of age (M = 26.40, SD = 1.78), whereas those in the part process goal group were between 20 and 43 years of age (M = 28.93, SD = 1.77). The institutional ethics committee approved the study and informed consent was obtained from each participant.

Apparatus and measures

Race Simulator. In line with previous research (Janelle, 2002; Mullen, Faull, Jones, & Kingston, 2014; Wilson, Smith, Chattington, Ford, & Maple-Hovart, 2006) a race driving task was used as this type of continuous motor task allows controlled testing of the psychophysiological variables without the movement artefacts associated with other sporting tasks. Participants completed a driving simulation task using the Colin McRae 2 race software (Codemasters, Warwickshire) presented on an 81 cm screen, using an analogue force feedback steering wheel and pedals. Participants drove a Ford Focus around a 3km tarmac track that included 32 bends. Participants used the driver's perspective to perform the task and drove in time trial mode to avoid any confounding effects of other cars on track. Performance was assessed using lap times recorded by the computer software, the number of

driving errors committed and an index of error severity. An error was recorded if, (a) the car spun, changed direction from its intended path, or crashed completely, resulting in a 3-point penalty; (b) if the entire car came off the track, 2-point penalty or (c) the car bumped or scraped the wall causing the fluidity of the car to be hindered but not resulting in a full crash, resulting in a 1-point penalty.

Cardiac Variables. Heart rate was recorded by telemetry using a Polar S810i monitor (Polar Kempele, Finland), which is a reliable and valid measure of R-R intervals (Gamelin, Berthoin, & Bosquet, 2006). Heart rate was continuously recorded throughout all of the experimental conditions. To standardize the epoch for spectral analysis, the middle 3 min of each measurement period was used. Artefact correction was conducted according to procedures used by Mullen et al. (2005). The artefact-free data were detrended using a smoothness priors based approach (Tarvainen, Ranta-Aho, & Karjalainen, 2002). Power spectrum densities (PSD) were estimated using autoregressive methods (Kubios HRV program, University of Kuopio, Finland). Compared to fast Fourier transforms, autoregressive algorithms produce a superior resolution, especially in short samples such as those used in the present study. Heart rate variability was estimated in the low frequency (LF; .07 – .14 Hz) and high frequency (HF; .15 – .40 Hz) spectral bands and is reported in normalized units (ms^2). The HF band was included as previous research has reported some sensitivity of this frequency band to anxiety and attention (Mullen et al., 2005). Heart rate (HR) was also included as a dependent variable. Previous research examining HRV and attention has largely used baseline-condition difference scores as dependent variables in subsequent statistical analyses (Mullen et al., 2005). In this study, raw condition scores were used and the resting baseline condition was included as an additional repeated measure to ensure statistical analyses were consistent for all psychophysiological dependent variables.

Salivary Alpha Amylase. Unstimulated whole saliva samples were collected for 4-minutes into preweighed universal containers using the passive drooling technique (Oliver et al., 2007). Practice of this technique was given in the familiarization session on day 1, before any main testing. On day 2, a baseline measure of saliva was taken, followed by further samples immediately after the task baseline and competitive conditions. Saliva flow rate was determined by dividing the volume of saliva by the collection time; where saliva volume was estimated by weighing the universal tube immediately after collection and assuming saliva density to be 1 g/mL (Oliver et al., 2007). Saliva flow rate is expressed as mL of saliva per minute (mL/min). Post weighed samples were transferred to eppendorfs and stored at -20°C until analysis. Analysis of sAA was completed by an enzyme kinetic method (α- Amylase Assay Kit, Salimetrics, State College, Pennsylvania, USA). Briefly, samples were thawed, centrifuged and diluted (final dilution1:200) with double distilled water before being added to a microtiter plate. After amylase substrate, preheated to 37°C, was added one column at a time and absorbance readings were obtained at exactly 1 and 3 minutes using a standard ELISA reader (Anthos Labtech HT2, Anthos, Krefeld, Germany). Salivary alpha amylase concentration (U/ml) was determined from the change in absorbance from the first to the second reading. Saliva amylase output (U/min) was then calculated by multiplying sAA concentration (U/ml) by saliva flow rate (mL/min).

Self-reported Effort. Perceived mental effort was assessed using the Rating Scale of Mental Effort (RSME; Zijlstra, 1993), which has demonstrated acceptable reliability in laboratory (r = 0.88) and real-life work settings (r = 0.78). This retrospective one-dimensional visual analogue scale requires participants to rate how much mental effort they perceived they invested into a task on a vertical scale ranging from 0 (*not at all effortful*), through 115 (*tremendously effortful*), to 150 (*no anchor*). Participants are required to mark

the scale at the point that best reflects the amount of mental effort invested in a task. The RSME was administered following the task baseline and competition conditions.

General Health. The General Health Questionnaire-12 (GHQ-12; Goldberg, 1992) was used to assess participants' psychological health and is standard protocol when examining sAA (Rohleder, Wolf, Maldonado, & Kirschbaum, 2006). The questionnaire consists of 12 items rated on a 4-point Likert scale. A total score was calculated, with scores ranging from 0 to 36. Typical scores range from 11-12, scores over 15 show signs of some distress and scores of 20 plus, suggest severe problems and psychological distress, and should be omitted from testing. No participants scored 20 or higher.

Cognitive State Anxiety. State anxiety was measured using the cognitive anxiety subscale of the revised Competitive State Anxiety Inventory-2 (CSAI-2R; Cox, Martens, & Russell, 2003). The CSAI-2R is a sport-specific, self-report inventory that has been shown to be a valid and reliable measure of cognitive and somatic anxiety and self-confidence by Cox et al. Participants rated their cognitive anxiety on a Likert scale ranging from 1 (*not at all*) to 4 (*very much so*). Item responses were summed, divided by 5 and multiplied by 10, resulting in a score range of 10 to 40 (Cox et al., 2003).

Post-experimental Questionnaire. The post-experimental questionnaire, which was used as a manipulation check to ensure participants had used their designated goals during testing, consisted of six statements answered on a 9-point Likert scale anchored by 1 (*not at all*) to 9 (*very much so*). The statements were: (a) I think I have completed the task as the instructions outlined; (b) I found it easy to use the goals; (c) The goal was relevant to my driving performance; (d) It was difficult to focus all my attention on my goal; (e) I feel that the use of goals helped my performance; and (f) Did you perceive your goal to be highly kinaesthetic in nature? (feel of the movement).

Procedure

The experiment consisted of six phases conducted over two days, modelled upon Mullen and Hardy's (2010) design. Phase 1 took place on day 1 and phases 2-6 took place on day 2. Participants were asked to not brush their teeth or chew gum and to restrict eating to 3 hours and drinking to 1 hour before attending the laboratory. The conditions were not counterbalanced as levels of sAA do not return to normal for up to 30-minutes post stress (Chatterton, Vogelsong, Lu, Ellman, & Hudgens, 1996; Rohleder, Wolf, Maldonado, & Kirschbaum, 2006); thus, a fixed order was used to prevent potential carry-over effects from the competition condition.

Day 1, Phase 1: Skill Acquisition. Participants learnt the driving task "by discovery" and were provided with no instructions or feedback on the driving task, which allowed participants to explore the dynamics of the task (Vereijken & Whiting, 1990). Participants learned the driving task by discovery, completing 14 double laps of the track with a five-minute rest after laps 5 and 10. Each double lap consisted of 64 corners. In total, participants completed 896 repetitions of the steering task, more than double the amount of practice used in previous studies examining the CPH (Hardy et al., 1996; Masters, 1992; Mullen & Hardy, 2010). Participants then received a brief explanation of the next day's session and the experimenter's intention to pay them £10. Participants were also fully briefed on the procedure for collection of HR and saliva samples and practiced the saliva sampling. Participants were told that the practice data would not be analyzed but would allow them to become comfortable with the procedure.

Day 2, Phase 2: Saliva and HR Sampling and Process Goal Training. The second day began with a 5-minute rest period to stabilize HR, followed by a 5-minute recording of HR and provision of a saliva sample, both of which served as resting baseline measures.

Participants were then reminded about the structure of the second part of the experiment and provided with information about the nature and efficacy of process goals. The information was instructional and also served to enhance participants' commitment and motivation to use the process goals. Participants were randomly assigned to either the part or holistic process goal group. Once assigned a group, participants self-selected their goals from master lists that were constructed with the assistance of two sport psychologists in line with driving instruction literature (Bentley & Langford, 2000; Senna, 1993). The process goals focused on hand movements in both conditions in order to avoid the potentially confounding effect of an internal versus external focus of attention (Wulf, 2007). All participants were also instructed to keep their vision focused on the track at all times during the driving task. The three holistic process goals all focused on the movement that participants used to manipulate the steering wheel when negotiating bends. The goals were designed so that they emphasized the feeling of the entire steering movement. The goals, "smooth", "glide", and "easy", were reinforced with instructions that reminded participants that the goal referred to the feeling of turning the steering wheel with their hands. In contrast, the part-process goals focused on the explicit knowledge required to negotiate the bends. Participants in the part process goal group also selected a single goal, the first of which was "9.15 grip", which focused on maintaining a relaxed grip on the steering wheel, with hands in the 9 and 3 o'clock positions on the wheel throughout the turn. The second goal asked participants to use the goal "outside hand", which focused on using the outside hand to turn the steering wheel; so, for a left hand bend, this meant that the right (outside) hand primarily turned the steering wheel, while the left (inside) hand followed the movement. The final goal was "small", which required a focus on making small adjustments to the steering wheel. The steering ratio was low enough to ensure that participants did not have to alter their grip in order to complete any of the turns, ensuring that both "9.15 grip" and "small" were realistic and achievable goals.

Phase 3: Warm-up. All of the participants were provided with the opportunity to practice using their selected process goal over one double lap.

Phase 4: Task Baseline. Following the warm up, participants rested for 5-min. At the beginning of the fifth minute, participants were provided with neutral instructions about the next two double laps. Immediately following the rest period, the participants completed the CSAI-2R, drove two double laps, and then provided a saliva sample and completed the RSME. There was then a 20-min rest period between the task baseline and competitive conditions. Participants remained seated and were asked to relax to allow any psychophysiological changes related to the driving task to return to baseline levels (Granger et al., 2007; Mullen et al., 2005).

Phase 5: Anxiety Intervention. Following the rest period, participants received instructions informing them that they had been randomly assigned to a team consisting of other individuals in the experiment, and were now involved in a competition. They were also informed that the £10 they had been offered would change, depending on how well they performed in the competition. Participants were told that the winning team would be the team who produced the fastest aggregate lap time and that each member of the winning team would win an additional £10. Participants were also told that those teams that did not win would lose some of their original £10 participation fee depending on where their team finished. The team that finished second would be deducted £2.50; the team in third, £5; fourth, £7.50; fifth, £9, with the team finishing last losing all of their original fee. Participants were assigned false individual target times that they were told they had to achieve in order for their team to have a chance of winning. Based on pilot testing, the target times were calculated by taking each participant's task baseline lap time minus 1.5 seconds. In sum, participants perceived the target time as being of both personal and team importance, creating an ego-threatening situation that was likely to increase cognitive state anxiety levels.

Phase 6: Competition phase. After reading the instructions, the participants filled in the cognitive anxiety subscale of the CSAI-2R, completed two double laps, provided a final saliva sample and then completed the RSME and the post-experimental questionnaire. Participants then received their competition prize money, were thanked for their participation and debriefed about the objectives of the experiment and the nature of their deception.

Results

Lap times, CSAI-2R, and RSME scores were analyzed using mixed two-factor analysis of variance (ANOVA; 2 x 2, Group x Condition, with repeated measures on the second factor). The same design was used to examine the driving error variables but this analysis was preceded by a multivariate analysis to examine number and severity of errors jointly. Normal distribution of HRV and sAA scores was obtained using logarithmic transformations. With the inclusion of the additional baseline condition for the psychophysiological variables, these analyses were conducted using two-factor mixed ANOVA (2 x 3, Group x Condition, with repeated measures on the condition factor). Significant effects were investigated using Tukey's HSD tests. Eta squared (η2) is reported to provide an indication of the magnitude of the effect size and 90% confidence intervals (CI) are also reported to estimate the precision of the effect size where η2 > .01 (Steiger, 2004).

INSERT TABLE 1 ABOUT HERE

The post experimental questionnaire scores were examined to confirm that participants had adhered to the treatment conditions, see Table 1. Mann Whitney U tests revealed that there were no significant differences between the part and holistic process goal groups (all *p*

> .05). The magnitude of the scores suggests that both groups generally adhered to their instructions.

INSERT TABLE 2 ABOUT HERE

For cognitive anxiety, there was a significant main effect for competition, $F(1, 28) = 21.50$, $p < .001$, $\eta^2 = .43$ (.19, .59), indicating that both groups recorded higher scores in the competitive condition, see Table 2. Neither the Group x Competition, $F(1, 28) < 1$, $\eta^2 = .01$ nor the main effect for group was significant, $F(1, 28) = 1.70$, $\eta^2 = .06$ (.00, .09). Means and standard deviations for driving performance variables can be found in Table 2. For lap times, ANOVA yielded a significant Group x Competition interaction, $F(1, 28) = 7.83$, $p < .01$, $\eta^2 = .22$ (.15, .40). Post hoc analysis revealed the part process goal group posted quicker times than the holistic process goal group in the task baseline, and the holistic process goal recorded faster lap times in the competition condition compared to the task baseline. No other pairwise differences were significant. Main effects were not examined in light of the significant interaction. For the error scores, the multivariate test statistics for the Group x Competition interaction and main effect for competition were not significant, $F(2, 27) < 1$, $\eta^2 = 0.02$ and $F(2, 27) < 1$, $\eta^2 = .02$. There was a significant multivariate main effect for group, $F(2, 27) = 4.10$, $p < .05$, $\eta^2 = .23$. Univariate follow-up ANOVA indicated that for both dependent variables, participants in the part group scored higher than those in the holistic group, $F(1, 28) = 5.02$, $p < .05$, $\eta^2 = .15$ (.07, .35) and $F(1, 28) = 6.47$, $p < .05$, $\eta^2 = .19$ (.02, .38), for number and severity of errors, respectively. Although the part process group were faster than the holistic group at baseline, this was at the expense of driving accuracy as the part group made significantly more errors (number and severity). The lower error scores of the holistic group also indicated that the quicker lap times recorded during the competition condition were not made at the expense of driving accuracy. Overall, the results show that the holistic process goal group were faster in the competition than at task baseline, while the lap

times of the part process goal group did not change. Eta squared values demonstrate that group differences accounted for between 15 and 19% of the variance in error scores.

INSERT TABLE 3 ABOUT HERE

Descriptive statistics for the psychophysiological variables can be found in Table 3. Due to equipment failure, HR data were not recorded for two participants, one in each group. Analysis of the HR data revealed a significant main effect for competition, $F(1.51, 39.15) = 24.55$, $p < .001$, $\eta^2 = .49$ (.28, .61); but no Group x Competition interaction or main effect for group, $F(1.51, 39.15) < 1$, $\eta2 = .00$ and $F(1, 26) < 1$, $\eta^2 = .002$, respectively. For HRVLF, there was no significant interaction, $F(2, 52) < 1$, $\eta^2 = .002$, or main effect for group, $F(1, 26) = 2.37$, $p > .05$, $\eta^2 = .01$. The main effect for competition was significant, $F(2, 52) = 11.20$, $p < .001$, $\eta^2 = .30$ (.12, .43). For HRVHF, there were no significant effects. Amylase responses were similar whether expressed as concentration or total output (concentration x flow rate), as saliva flow rate was unchanged between groups or conditions ($p = .79$ for the Group x Condition interaction). Consequently, sAA concentration (U/ml) was used as the dependent variable in the main analysis, which revealed no significant Group x Competition interaction, $F(2, 56) < 1$, $p > .05$, $\eta^2 = 0.02$, or main effect for group, $F(1, 28) = < 1$, $p > .05$, $\eta^2 = .01$. There was a significant main effect for competition, $F(2, 56) = 9.99$, $p < .001$, $\eta^2 = .26$ (.10, .43). Post hoc analyses on the significant competition main effect for HR and sAA concentration, indicated that levels of both variables increased from resting baseline to task baseline and further still from task baseline to the competition condition. This pattern was repeated for HRVLF, but reflected reductions in spectral power. Analysis of the RSME scores yielded a significant main effect for competition, $F(1, 28) = 28.32$, $p < .001$, $\eta^2 = .50$ (.26, .64), with mental effort perceived to be higher during competition, with no other significant effects (both *F*s < 1). In summary, the anxiety intervention caused increases in

HR, sAA, and RSME, and a significant reduction in the patterning of HRVLF. The magnitude of these effects ranged from 26% to 50% of variance accounted for.

Discussion

Our prediction regarding the utility of holistic process goals was supported, as the holistic process goal group outperformed the part process goal group in the competition condition. In this study, the holistic group were significantly slower than the part group at task baseline, while in the competitive condition, the holistic group improved their performance to a level equivalent to the part group; however, this improvement must be viewed in the context of the driving error scores. Participants in the holistic group made significantly fewer and less severe errors than the part group across both task baseline and competitive conditions. Taken together, this pattern of results suggests that performance was equivalent at baseline, while the improvements in lap times made by participants using holistic process goals in the competitive condition, combined with fewer and less severe errors indicates that, overall, this group outperformed the participants who used part process goals. As such, the pattern of results for the performance variables supports the existing literature in this area (Gucciardi & Dimmock, 2008; Mullen & Hardy, 2010). The interaction between process goal and competition conditions produced effect sizes accounting for 15%, 19% and 22% of variance in the performance scores, for number of errors, severity of errors and lap times, respectively. The relatively small range in the effect size CI for lap times gives us confidence that the reported effect size is relatively precise. For the error scores, the much broader range of CIs, ranging from .007 to .38, leaves us less able to draw conclusions about the accuracy of the effect sizes reported. The process goal instructions and the differential performance at task baseline suggest that the participants in the holistic and part groups may have achieved their performance scores using different strategies; the slower times recorded by the holistic group at baseline suggests that they were focused more on driving smoothly,

resulting in less errors than the part group. In the competition condition, however, it appears that the strategy adopted by the holistic group enabled them to improve their lap times, while maintaining the error rate recorded at task baseline. Clearly the different process goals resulted in contrasting approaches to the speed-accuracy trade off and a more detailed examination of how this was achieved would enable us to say more about the how strategies employed affected car control. For example, Wilson, Chattington et al. (2007) used a potentiometer to measure the displacement of the steering wheel, which could help reveal how the process goal conditions affected the "smoothness" of the steering.

While it appears that holistic process goals do offer a performance advantage over part process goals when performers are anxious, there is no direct evidence (i.e., performance decrements) that part process goals cause lapses into conscious processing that impairs performance. The results reported here are in line with those of Mullen and Hardy (2010), who suggested that the most parsimonious explanation for their findings was that conscious processing *was* activated. They argued that the relative impairment of the part group compared to the holistic group during competition provided the basis for drawing the inference that such goals do cause conscious processing. Despite this position, there is still no evidence of direct conscious processing impairment in any of the experiments that have examined the process goal paradox.

The HRVLF response reported here is in contrast with previous studies that have reported no significant effects for the HRVLF band (Filaire et al., 2010; Mullen et al., 2005; Wilson, Smith et al., 2007). The HRVLF response was similar for both process goal groups, decreasing from baseline to task baseline and further still to the competition condition. This pattern suggests that if the LF band is reflective of increased mental effort, this is more likely to be associated with compensatory effort (Eysenck & Calvo, 1992) rather than the task-related effort associated with conscious processing (Mulder, 1992). This compensatory effort

explanation becomes more compelling when examined in light of the performance scores, which revealed that the holistic group improved their performance, while the part group maintained theirs in the competition condition; thus, performance effectiveness was maintained (part group) or improved (holistic group) but at the expense of processing efficiency in both groups. The RSME scores also add weight to this suggestion as they mirrored the HRVLF pattern. The increases in HR and sAA from baseline to task to competition contrasted with those of HRVLF, and are in line with evidence that these variables respond to increased anxiety as a result of increases in sympathetic activity (Filaire et al., 2010). Typically, however, the HRVLF response follows the same pattern as HR and sAA, that is, it increases (Nater et al., 2005; Wiethof, 1986, cited in Mulder, 1992). This pattern was not evident in this study and the decreases reported here suggest that the dynamics of HRVLF band may be sensitive to compensatory anxiety-related mental effort.

The inclusion of sAA gives us new insight into the competitive state anxiety response, adding a neuroendocrinological dimension. The increases in sAA concentration in both groups from resting baseline to task baseline and from task baseline to the competitive condition are in line with previous research that has examined the sAA response to psychosocial stress (Bosch et al., 2003; Chatterton et al., 1996; Nater et al., 2006; Rohleder et al., 2006). As a result of these studies, sAA has been supported as a measure of sympathetic activity. As such, the pattern of sAA in this experiment lends support to the suggestion that the decreases in HRVLF power represent increases in compensatory effort as participants appear to have mobilized resources to help deal with the perceived threat indicated by the increase in cognitive anxiety (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007). Although activity in the HRVLF band is mediated by both sympathetic and parasympathetic activity (Berntson et al., 1997), the absence of any differences in the HRVHF response, which is reflective of respiratory sinus arrythmia, an established indicator

of parasympathetic activity (Berntson et al., 1997), suggests that the changes in HRVLF activity in response to the competition stressor were not influenced by shifts in power in the high frequency band. The consistent pattern of effect sizes (range = 26-30% of variance accounted for) and the associated confidence intervals produced by the competition main effect for the psychophysiological variables as a whole suggests that there is a moderate to large mobilization of resources to help cope with the effect of competition. Future research should seek to replicate this pattern of effects.

Although the performance differential of the process goal groups during the competitive phase is most parsimoniously explained by conscious processing, more direct measures of conscious processing would allow us to draw more concrete conclusions. Electroencephalography is one technique that may enable researchers to gain a more direct insight into conscious processing. The use of these psychophysiological indices are important in this line of research, as an insight into the activation states underlying performance might help us better understand the causal mechanisms of the anxiety response. It is also possible that stronger anxiety interventions might lead to more pronounced conscious processing effects. In the present study, although there were significant increases in cognitive anxiety, absolute levels were lower than those typically reported by athletes in competition (Mullen et al., 2005). The effect size produced by the anxiety intervention (.43) corresponds to those reported in similar research (e.g., Mullen & Hardy, 2010, $\eta p^2 = .42$). However, the absence of CIs on the reported effect sizes in previous studies makes direct comparisons difficult. It is also possible that the CSAI-2R used in the present study may be insensitive to the full complexity of the anxiety response, which has often been shown to be adaptive in nature (Eysenck & Calvo, 1992). The CSAI-2R and the CSAI-2 are founded upon the traditional worry-emotionality conceptual framework, which recent research has suggested is unable to capture the full complexity of the anxiety response (Cheng, Hardy, & Markland, 2009).

Future research might benefit from the inclusion of alternative measures of state anxiety, such as that developed by Cheng et al. In addition, future studies should also include confidence intervals around effect sizes to allow readers to determine the precision of the effects reported and to allow for possible use in subsequent meta-analyses.

The post-experimental questionnaire (PEQ) gave detailed feedback on participants' perceptions about their adherence to their assigned goal and the extent to which they believed that the goal helped or hindered their performance. The PEQ was more extensive than the manipulation check used in similar studies (Mullen & Hardy, 2010; Wilson, Chattington et al., 2007; Wulf, 2007). Manipulation checks are essential to be confident about adherence to treatment conditions and the PEQ indicates that this was adequate in both goal groups. However, the PEQ still only sheds limited light on the issue of participants' experiences and more sensitive open-ended questions could be employed in future research.

The present study was not without limitations. One point of note is the precision of many of the relatively large effect sizes reported in this study. For several variables, the confidence intervals ranged around 30 points. This relatively large range makes us less confident about the actual size of the effect. Greater statistical power would probably result in a set of effect sizes with a narrower band of confidence intervals. The absence of counterbalancing is also potentially an issue; however, the rationale for the fixed ordering of conditions was based on pilot work, which indicated that where the competitive condition preceded the baseline condition, participants believed that the baseline was a further competitive condition, despite being assured otherwise. The fixed order was also determined by the sAA response to stressors, which can take up to 30-min to return to baseline, while recovery from tasks completed in neutral conditions is much quicker (Nater et al., 2006). Some readers might argue that a within-subjects treatment of the process goal conditions could have been adopted; however, repeated measures on the process goals might have confused participants

and where such multiple treatment interference is a possibility, random assignment to separate goal conditions is preferred (cf. Mullen & Hardy, 2010). The principal researcher, who was not blind to the purpose of the study, assessed the severity of the errors committed by the participants, potentially leading to bias. Ideally, two scorers who are blind to the study aims should complete the scoring and inter-rater agreement should be calculated. It is clear that HRV alone provides limited information about the mechanisms underlying changes in mental effort. More extensive measures of autonomic activity are necessary to get a more complete picture of the mechanisms underlying changes in HRV. The innovative use of sAA in this experiment goes some way to achieving this.

In terms of applied implications, the current findings support the use of holistic process goals for skilled but anxious athletes in competition. Process goals are often used within pre-performance routines in preparation for skill execution (Hardy, Jones, & Gould, 1996). These routines often include part-process oriented information, and the evidence presented here suggests that athletes may benefit from using globally focused information in their routine. This paper has tested these types of goals in a driving task, but these could be easily adopted in other sports, for example “pendulum” would help a golfer focus on the feeling of the movement when putting, or “extend” might aid a gymnast during a flic flac movement. Holistic process goals are not the only solution to the process goal paradox. Hardy et al. (1996) suggested that the process goals might not always be task focused. For example, athletes might include emotion-focused goals, such as being relaxed, to keep their focus away from task execution. Applied practitioners should remain sensitive to the variety of process goals available to performers and be especially vigilant where athletes use routines that contain task-focused goals. In such circumstances, the goals should be holistically focused.

Conclusion

In summary, the experiment reported here adds to the evidence that holistic process goals can help skilled but anxious performers avoid the potentially debilitating conscious processing effects associated with the use of part process goals. The psychophysiological measures adopted also suggest that the performance levels recorded by both process goal groups in the competitive condition were achieved using compensatory effort. Future research should seek to build on this promising interdisciplinary approach to provide a fuller picture of the relationship between anxiety, attention and performance.

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Table 1. Mean (*SD*) post experimental questionnaire responses

Question (1-9)	M	SD
Question 1		
Part process	8.1	1.1
Holistic process	8.1	0.6
Question 2		
Part process	6.8	1.6
Holistic process	6.9	1.3
Question3		
Part process	7.7	1.1
Holistic process	7.1	1.4
Question4		
Part process	6.0	2.3
Holistic process	6.0	2.8
Question5		
Part process	6.5	1.9
Holistic process	5.3	2.0
Question6		
Part process	6.8	1.1
Holistic process	6.3	1.3

Table 2. Mean (*SD*) for cognitive anxiety, lap times (secs), number of errors, and error severity

	Task baseline		Competition	
Measure (range of scores)	*M*	*SD*	*M*	*SD*
Cognitive anxiety (10-40)				
Part process	13.6	4.3	16.4	3.2
Holistic process	15.3	4.1	18.6	5.0
Lap times				
Part process	235.0	32.1	237.1	30.3
Holistic process	269.2	52.6	236.4	25.9
Number of errors				
Part process	3.3	4.1	4.1	2.9
Holistic process	1.7	2.2	1.7	2.0
Error severity (1-3)				
Part process	5.7	7.3	6.8	4.7
Holistic process	2.5	3.2	2.4	3.1

Table 3. Mean (*SD*) of heart rate, saliva and self-reported mental effort measures

	Resting baseline		Task baseline		Competition	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
Heart rate (bpm)						
Part process	72.2	11.9	80.4	23.6	84.6	19.5
Holistic process	69.2	11.2	77.4	11.8	81.3	13.4
HRV low frequency band (ms^2)						
Part process	409.7	357.4	217.7	146.0	179.6	162.7
Holistic process	677.8	532.8	394.9		212.5	181.1
HRV high frequency band (ms^2)						
Part process	296.5	317.8	160.7	224.3	81.4	55.0
Holistic process	125.0	53.8	252.2	264.7	145.4	155.5
sAA (U/ml)						
Part process	38.2	28.2	38.7	31.5	51.3	37.0
Holistic process	33.6	24.8	43.3	29.5	45.4	21.4
Mental Effort (0-150)						
Part process			89.5	19.6	99.3	17.9
Holistic process			92.0	22.9	101.3	25.1

Note: HRV = heart rate variability, sAA = salivary alpha amylase. HRV and sAA are raw values for ease of interpretation.