Experiment 3

Method

Participants

Based on the effect size (.08) pooled from Nevicka et al.'s (2016) studies (Studies 2-3) testing narcissism × ego threat interactions on cognitive performance, we needed a minimum sample of 101 participants to have adequate power (.80) to detect our hypothesized interaction effect at .05 alpha level. We recruited 117 university students from a UK University (*M* age = 23.57, *SD* = 4.05; 46 males).

Tasks

We programmed and tested a letter transformation task using PsychoPy (Peirce, 2007). We provided the task instructions, gave the manipulations, and assessed performance via the computerized testing system. The letter transformation task (Hamilton et al., 1977) requires participants to transform a random letter string a given distance to obtain another letter string. For example, the instruction 'A + 3' requires participants to transform a single letter string 'A' by counting forward for three letters following the English alphabet, to get to an answer of 'D'. We used the single-string task where only one letter needed to be transformed in one trial at a distance ranging from 1 to 4 letters, with both forward (e.g., D + 4) and backward (e.g., Z - 4) transformations to make the task more difficult. Using the single-letter version of letter transformation helps to minimize the potential confound of movement processing (i.e., the time spent on pressing a responding button after working out the transformation) on cognitive processing (i.e., the time spent on transforming the given letter with a required distance).

Performance

A timer started each time when the testing system began to display a task trial and stopped when the participant pressed a responding key. We used the average time taken as the

major performance outcome but controlled for accuracy in all analyses to remove any possible speed-accuracy trade-offs. Using a timed task allowed us to test whether the performance effects demonstrated in self-paced tasks in Experiments 1 (basketball free throw) and 2 (golf-putting) would be generalizable to performance settings where reaction time also matters.

Design

Participants performed the letter transformation under practice, low pressure, and high pressure. Participants attended an individual session to complete all experimental conditions.

Experimental conditions

Prior to starting, we used standardized instructions to convince our participants that the experimental tasks were important and relevant to them. We also informed participants that we intended to pay them £5 for participation to thank for their time and commitment based on the successful completion of all experimental tasks.

Practice. We familiarized participants with our experimental tasks by providing detailed task instructions followed by free practicing trials. Participants had an opportunity to practice ten trials of letter transformation, which is consistent with studies using the same tasks (e.g., Hardy, Beattie, & Woodman, 2007).

Low-pressure condition. On completion of the practice condition, the testing system instructed participants that they had a last opportunity to practice. The system further displayed instructions to participants, encouraging them to practice the task for as many trials as they wanted. The system then instructed participants that during this last practice their average speed and accuracy would be automatically recorded and compared to a database that consisted of historical records of other participants' speed and accuracy doing the same tasks from our previous studies. Such fabricated instruction was necessary for manipulation purposes (see *High-pressure condition*). Before starting the final practice, the system

instructed participants to complete each trial as fast as possible and to practice as many trials as they wanted in order to optimize their task preparation for the final test coming after.

High-pressure condition. On completion of the low-pressure condition, the testing system automatically displayed fake but precise feedback regarding participants' percentile positions of speed and accuracy in their last practice (i.e., "Your percentile ranking of speed in letter transformation – 10.9%"; "Your percentile ranking of accuracy in letter transformation – 78.6%"). We further interpreted the feedback to our participants:

> The feedback suggests that, compared to people participating in our previous studies performing the same tasks, your speed seems quite slow in the previous session – faster than only 10.9% people in letter transformation, despite your accuracy being ranked higher than average people.

We gave negative feedback on the main performance outcome (i.e., speed) to increase performance pressure for participants (see also Nevicka et al., 2016). As participants are more aware of their relative accuracy rather than of their speed in letter transformation (Hamilton et al., 1977), we provided neutral-to-positive feedback on accuracy to minimize participant suspicion of the feedback. After giving negative feedback, the testing system instructed participants that they would be competing with over one hundred other participants in the final test. The system gave further instructions that participants' performances would be compared to the same historical records as in the last practice, and the improvement in their percentile rankings would determine their cognitive performance. To strengthen perceived task importance, the system provided further instructions that the more one improves from the last practice to the final test, the more capable one will be in scenarios involving learning new skills, creating innovative ideas, and solving different problems in real life.

In addition, the system displayed pressurized instructions that, while the top three performers who improved the most would be awarded a monetary prize of £50, £25, and £10,

respectively, those who failed to maintain their previous percentile rankings would not receive the £5 participation allowance. The system also informed participants that a full list of rank-ordered performance improvement would be sent to all participants on completing all experimental sessions, with a highlight to promote both the top-ten and the bottom-ten participants. In reality, all participants were paid £5 on top of any prize money, and the list of participants' rankings was not released. Following the aforementioned pressurized manipulations, we provided the following instructions:

> This is a serious test, but you are not forced to continue if you are unwilling to. Are you sure you want to continue to complete the test?

Participants entered the final test only if they agreed. Before starting the final test, the system displayed a final reminder:

> This is a difficult and demanding test, you need to complete one hundred trials of the letter transformation task. Try to complete the tests as quickly as possible.

Measures

Narcissism. We assessed narcissism using the NPI-40 as described in Experiment 2. We generated a score for adaptive narcissism (14-item; $M = 6.32$, $SD = 3.44$, $\alpha = .79$), maladaptive narcissism (18-item; $M = 5.97$, $SD = 3.91$, $\alpha = .79$), and grandiose narcissism (NPI total score; $M = 15.84$, $SD = 7.79$, $\alpha = .88$).

Cognitive anxiety. We assessed cognitive anxiety prior to each experimental condition using the MRF-L as described in Experiment 2.

Mental effort. We assessed mental effort after each experimental condition using the RSME as described in Experiment 2.

Cardiac activity. We measured cardiac activity using a Polar V800 heart rate monitor. The Polar V800 demonstrates excellent agreement with a 3-lead electrocardiograph (Giles, Draper, & Neil, 2016), and substantial research has adopted the Polar V800 in assessing

cardiac activity in relating to autonomic responses under pressure (e.g., Beltrán-Velasco, Bellido-Esteban, Ruisoto-Palomera, & Clemente-Suárez, 2018). We used the Kubios HRV Software (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014) to analyze recordings. We analyzed artifact-free data only.

We assessed heart rate to provide physiological insights into effort in order to examine the *trying harder* position, with increased heart rate reflecting higher levels of effort (Mulder, 1992). To reduce the likelihood of any confound on heart rate, we used age-adjusted heart rate, which was computed based on the percentage of the predicted maximum heart rate (220-age) for each participant (Astrand, Rodahl, Dahl, & Strømme, 2003).

In addition, we assessed the root mean square of successive normal to normal [R-R] intervals (r-MSSD), a time domain measure of heart rate variability, to provide insights into the efficiency of task processing in order to examine the *trying smarter* position. r-MSSD provides an index of cardiac vagal control (Achten & Jeukendrup, 2003), which is positively associated with affective regulation, attentional control, and goal-directed executive function (Thayer & Brosschot, 2005). It also reflects the activation of prefrontal cortex that is positively related to one's ability to self-regulate during task performance (Thayer, Hansen, Saus-Rose, & Johnsen, 2009). Typically, processing efficiency and r-MSSD reduce as anxiety increases (e.g., Eysenck & Calvo, 1992; Thayer et al., 2009). Therefore, if participants *try smarter*, one would expect them to be immune from this typical anxiety response, and instead display maintained or increased r-MSSD to reflect relatively greater efficiency.

Number of trials practiced. The number of trials practiced indicated various potential confounds related to performance. For example, a participant with lower levels of capacity or confidence, higher levels of motivation or perceived task importance, may practice more trials to better prepare. In the low-pressure condition, we instructed participants to practice as many trials as they wanted to prepare for their final test and recorded the number of trials

they practiced. We used this variable as a covariate in all analyses.

Procedure

We promoted the study and recruited participants via sending emails to university students and posting posters around the university campus. The experiment took place in a quiet testing room. Participants received standard study information and provided consent. Next, we attached the Polar V800 to participants and asked them to sit still for two minutes to check if the heart rate monitor was working properly. After completing the NPI-40, participants performed the familiarization trials, followed by the low-pressure and high-pressure conditions. Participants completed the MRF-L immediately after the manipulations in the low and high-pressure conditions and the RMSE on completion of these conditions. We measured cardiac activity continuously during the task performance. On completion of all experimental tasks, we fully debriefed participants of the details in the experiment and the rationale behind the procedures. We also thanked all participants and paid them £5. At the end of all experimental sessions, we awarded prize money to the top three performers.

Statistical Analyses

Preliminary analyses

A paired *t* test revealed a significant increase in cognitive anxiety from low ($M = 3.17$, $SD = 1.82$) to high pressure condition ($M = 5.09$, $SD = 2.33$), $t\ (116) = 9.78$, $p < .001$, 95% CI [1.53, 2.21], Cohen's $d = .91$. Despite the stationarity of our cognitive task, we detected artifacts in the R-R intervals for six participants, so we removed their psychophysiological data. The average length of measurement epoch for r-MSSD in the letter transformation task was 220.68 seconds ($SD = 169.29$) in the low-pressure condition and 627.76 seconds ($SD = 223.99$) in the high-pressure condition. All measurement segments fulfilled Mulder's (1992) rule of at least 30 seconds of a short recording epoch for assessing high-frequency bands or its corresponding time domain measure of heart rate variability (i.e., r-MSSD). Table S3.1-3.2

provides descriptive statistics and correlations between study variables.

Main Analyses

As in Experiments 1 and 2, we generated the residualized scores for the time taken, accuracy, mental effort, age-adjusted heart rate, and r-MSSD (hereafter we use the variable name to refer to the residualized score). Among the residualized scores, we excluded extreme values (i.e., one in mental effort, four in r-MSSD) that were three standard deviations from the variable mean because these high values of standardized residuals increase standard errors and reduce statistical power in regression analyses (Cohen, Cohen, West, & Aiken, 2003). No multivariate outliers were found after removing extreme univariate scores. The analytical sample in each of our analyses after excluding outliers met our required sample size. We controlled for age, numbers of trials practiced, and accuracy in all our analyses, and performed the same regression analyses described in Experiment 1 and 2. All assumptions for regression were satisfied.

References

Achten, J., & Jeukendrup, A. E. (2003). Heart rate monitoring: Applications and limitations. *Sports Medicine*, *33*, 517–538. https://doi.org/10.2165/00007256-200333070-00004

Astrand, P. O., Rodahl, K., Dahl, H. A., & Strømme, S. B. (2003). *Textbook of Work Physiology: Physiological Bases of Exercise*. Human Kinetics. Retrieved from https://books.google.co.uk/books?id=BC9SiAsUPqsC

Beltrán-Velasco, A. I., Bellido-Esteban, A., Ruisoto-Palomera, P., & Clemente-Suárez, V. J. (2018). Use of portable digital devices to analyze autonomic stress response in psychology objective structured clinical examination. *Journal of Medical Systems*, *42*, 35. https://doi.org/10.1007/s10916-018-0893-x

Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. (2003). *Applied multiple regression/correlation analysis for the bahvioural sciences* (3rd ed.). Hillsdale: Erlbaum.

Giles, D., Draper, N., & Neil, W. (2016). Validity of the Polar V800 heart rate monitor to measure RR intervals at rest. *European Journal of Applied Physiology*, *116*, 563–571. https://doi.org/10.1007/s00421-015-3303-9

Hamilton, P., Hockey, G. R. J., & Rejman, M. (1977). The place of the concept of activation in human information processing theory: An integrated approach. In S. Dornic (Ed.), *Attention and performance (Vol. VI)*. Hillsdale, NJ: Erlbaum.

Hardy, L., Beattie, S., & Woodman, T. (2007). Anxiety-induced performance catastrophes: investigating effort required as an asymmetry factor. *British Journal of Psychology*, *98*(Pt 1), 15–31. https://doi.org/10.1348/000712606X103428

Mulder, L. J. M. (1992). Measurement and analysis methods of heart rate and respiration for use in applied environments. *Biological Psychology*, *34*, 205–236. https://doi.org/10.1016/0301-0511(92)90016-N

Nevicka, B., Baas, M., & Ten Velden, F. S. (2016). The bright side of threatened narcissism:

Improved performance following ego threat. *Journal of Personality*, *84*, 809–823. https://doi.org/10.1111/jopy.12223

Peirce, J. W. (2007). PsychoPy: Psychophysics software in Python. *Journal of Neuroscience Methods*, *162*, 8–13. https://doi.org/10.1016/j.jneumeth.2006.11.017

Tarvainen, M. P., Niskanen, J. P., Lipponen, J. A., Ranta-aho, P. O., & Karjalainen, P. A. (2014). Kubios HRV - Heart rate variability analysis software. *Computer Methods and Programs in Biomedicine*, *113*, 210–220. https://doi.org/10.1016/j.cmpb.2013.07.024

Thayer, J. F., & Brosschot, J. F. (2005). Psychosomatics and psychopathology: Looking up and down from the brain. *Psychoneuroendocrinology*, *30*, 1050–1058. https://doi.org/10.1016/j.psyneuen.2005.04.014

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine*, *37*, 141–153. https://doi.org/10.1007/s12160-009-9101-z

Table S3.1

*Descriptive statistics and correlations between study variables in the letter transformation task under low pressure condition (*n = *117)*

Measure	1	2	3	4	5	6	7	8	9	10	11
(1) Age	–	.01	.04	-.03	-.06	.09	-.05	-.16	.23*	.02	-.13
(2) NPI-40		–	.82**	.87**	-.16	.15	-.17	-.13	.26**	.09	-.18
(3) AN-14			–	.52**	-.17	.19*	-.13	-.16	.23*	.06	-.19
(4) MN-18				–	-.08	.08	-.08	-.09	.28**	.08	-.16
(5) Anxiety					–	.15	.07	-.02	-.04	.26	-.01
(6) Mental Effort						–	.11	-.10	.05	.03	.02
(7) AgHR (n =111)							–	-.52**	.03	.16	-.01
(8) r-MSSD (n=111)								–	-.01	.03	-.06
(9) TNTP									–	.25**	-.16
(10) Time Taken										–	-.38*
(11) Accuracy											–
Mean	23.57	15.84	6.32	5.97	3.17	116.01	39.22	43.04	32.91	7.13	.79
SD	4.04	7.79	3.44	3.91	1.81	26.31	5.61	19.57	24.41	3.06	.19

Note. NPI-40 = 40-item Narcissistic Personality Inventory (range: 0-40); AN-14 = Adaptive Narcissism (range: 0-14); MN-18 = Maladaptive Narcissism (range: 0-18); AgHR = Age-adjusted percentage of maximum heart rate (in %); r-MSSD = Root mean square of the successive differences of the normal to normal R-R intervals (in millisecond); TNTP = Total number of trials practiced.

* $p < .05$; ** $p < .01$

Table S3.2
*Descriptive statistics and correlations between study variables in the letter transformation task under high pressure condition (*n *= 117)*

Measure	1	2	3	4	5	6	7	8	9	10
(1) Age	–	.01	.04	-.03	-.17	.06	.04	-.14	.01	-.14
(2) NPI-40		–	.82**	.87**	.12	.12	-.18	-.03	-.14	-.07
(3) AN-14			–	.52**	-.01	.13	-.12	-.11	-.13	-.09
(4) MN-18				–	.19*	.10	-.11	-.02	-.14	-.05
(5) Anxiety					–	.07	.04	-.04	.09	-.02
(6) Mental Effort						–	.05	-.07	-.01	.01
(7) AgHR (n =111)							–	-.54**	.16	.09
(8) r-MSSD (n=111)								–	.08	-.09
(9) Time Taken									–	-.17
(10) Accuracy										–
Mean	23.57	15.84	6.32	5.97	5.09	129.52	39.97	43.11	6.28	.83
SD	4.04	7.79	3.44	3.91	2.33	20.30	6.01	21.70	2.24	.16

Note. NPI-40 = 40-item Narcissistic Personality Inventory (range: 0-40); AN-14 = Adaptive Narcissism (range: 0-14); MN-18 = Maladaptive Narcissism (range: 0-18); AgHR = Age-adjusted percentage of maximum heart rate (in %); r-MSSD = Root mean square of the successive differences of the normal to normal R-R intervals (in millisecond).
* $p < .05$; ** $p < .01$