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STRONG EMOTIONS, A WEAKNESS OR STRENGTH?

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Abstract

This experimental study investigated whether affective states influence physical strength. A sample of 32 university students participated in two interventions and one control condition. The interventions were a time-constrained puzzle and a guided, anger focused visualisation. After each intervention and during the control, participants tested their grip strength with a hand dynamometer and estimated eight different affective states through continuum-scales. Participants were the strongest during the control, being statistically weaker during the puzzle intervention compared to control. Both interventions induced multiple affective states, including anger. A simple linear regression gave a statistically significant model where 13% of the variation in grip strength difference, between the puzzle intervention and control, could be explained by the difference in anger between the same trials. Participants' difference in grip strength between the trials could be predicted as -5.08 + 0.09. For each value that the puzzle intervention rated higher in anger, grip strength was increased by 0.09 kg compared to the control. The model showed a positive moderate correlation. Higher anger during the puzzle intervention increased strength output relative to the control, despite showing a lower mean grip strength. Anger, under the proper circumstances, appear to increase strength output, but more research is needed.

Keywords: affect, anger, emotions, strength, hand dynamometer

Sammanfattning

Denna experimentella studie undersökte hur affektiva tillstånd påverkar vår fysiska styrka. Ett urval bestående av 32 universitetsstudenter deltog i två interventioner och ett kontrollförsök. Interventionerna var ett tidsbegränsat pussel och en vredes fokuserad, guidad visualisering. Efter varje intervention och under kontrollen mätte deltagarna sin greppstyrka med en handdynamometer och skattade åtta olika affektiva tillstånd genom en kontinuum-skala. Deltagarna var starkast under kontrollen och var statistiskt sett svagare under pusselinterventionen än kontrollen. Båda interventionerna frambringade flera olika affektiva tillstånd, inklusive vrede. En enkel linjär regression gav en statistiskt signifikant modell, där 13% av variationen i greppstyrkans skillnad mellan pusselinterventionen och kontrollförsöket kunde förklaras av skillnad i vrede mellan dessa tillfällen. Deltagarnas skillnad i greppstyrka mellan tillfällena kunde prediceras enligt modellen -5.08 + 0.09. För varje värde som pusselinterventionen gav högre vredes skattning, ökade greppstyrkan med 0.09 kg jämfört med kontrollen. Sambandet hade en moderat positiv styrka. Högre vrede under pusselinterventionen ökade greppstyrkan i förhållande till kontrollen, trots ett lägre uppvisat medelvärde i greppstyrka. Vrede, under rätt omständigheter, verkar öka maximal styrka, men det behövs mer forskning.

Nyckelord: affekt, vrede, emotioner, styrka, handdynamometer

Strong emotions, a weakness or strength?

Silvan Tomkins proposed in the mid 1900's that we are born with nine basal affects: interest, enjoyment, surprise, distress, fear, shame, anger, disgust and dismell (Frank & Wilson, 2020). These can be subdivided into positive, neutral, and negative. Enjoyment and interest are categorised as positive as they engage and soothes us. Surprise is categorised as neutral. The rest are categorised as negatives, mostly encouraging us to avoid situations in which they appear. Affect can be defined as a collective term for feeling states such as emotions and moods (Niven, 2013). Our basal affective states are used as motivators, sources of information about our needs and means of communicating (Frank & Wilson, 2020). Despite anger originally being deemed a negative state of affect, it is difficult to categorise it as either positive or negative (Watson et al., 2016). Anger serves both the function of signalling oneself to overcome obstacles and to signal disagreement towards others (Williams, 2017). Anger can therefore fill the need of overcoming challenges for oneself and set boundaries in relation to others (Bergsten, 2015).

Affect and emotion are two notions often used interchangeably. They can be distinguished from one another by the subjective experience and the physiological processes. Affective states relate to the biological mechanisms while emotion refers to the subjective experience (Bergsten, 2015). This thesis will use whichever term was used in a study when referring to said study, otherwise the term affect, defined as a collective term for feeling states, will be used.

Emotions can be regulated up or down and are important processes for using emotions in functional ways to achieve goals, fulfil needs and support our health (Gross, 2015). Emotional regulation (ER) can be defined as the processes within the individual that control which emotions are had, when they are had, and how they are experienced and expressed (Artino, 2011). Two ER strategies common in research are cognitive reappraisal and expressive suppression (Kobylińska & Kusev, 2019). Cognitive reappraisal, sometimes labelled cognitive change, involves altering how an individual views a situation to alter its emotional impact (Gross, 2015). Expressive suppression attempts to inhibit a chosen emotion from being expressed (Kobylińska & Kusev, 2019). The latter of the two has been linked to more negative emotions and is overall more cognitively taxing (John & Gross, 2004). Additional ER strategies include selecting or modifying situations, behavioural acts that alter one's physiological state (e.g., consuming food or drugs) and directing one's attention (Gross, 2015). The success of an ER strategy is hard to predict. Personality

and tendency toward reappraisal as strategy have both been shown to explain successful ER (Morawetz et al., 2017) and be unrelated to successful usage of an ER strategy (Scheffel et al., 2019).

Emotions are important in the world of sports and have been shown to influence performance in multiple ways (Jekauc et al., 2021). Different emotions may be useful for different tasks. One frequently studied emotion in relation to sport is anger. An increase in anger has led to greater performance in gross muscular tasks (Woodman et al., 2009). It has also been noted that anger can hinder sport performance that requires fine motor movement and precision (Jekauc et al., 2021). A self-induced emotional state of both anger and happiness have increased physical performance, while anxiety and sadness have shown to not differentiate from a neutral state (Rathschlag & Memmert, 2013). Richard Lazarus, through his cognitive-motivational-relational theory of emotion, made a distinction between anger directed outwards and anger centred on oneself through self-blame (Lazarus, 2000). He hypothesised that channelling anger through self-blame would be worse for sport performance. Increases in specifically strength exertion, derived from a state of anger, has shown to be suppressed when channelling anger towards the self (Davis et al., 2010).

Changes to sport performance may be attributed to different physiological responses such as arousal, that can follow an activation of an affective state. Arousal can be defined as a physiological activation, can either facilitate or debilitate performance and is related to the person's appraisal of a situation (*APA Dictionary of Psychology*, n.d.). The autonomic nervous system and the hypothalamic–pituitary–adrenocortical system, both indicating arousal, have shown greater activity during negative affective states (Gunnar & Adam, 2012). Affective states can also involve cognitive changes to attention, working memory and cognitive control (Okon-Singer et al., 2015).

Turner & Jones (2018) have presented various theories that attempt to explain the relationship between arousal and sport performance. One approach is the inverted U-hypothesis, originally presented by Yerkes & Dodson (1908), where a moderate level of arousal is desired to perform. When a sport demands a more strength-based performance during a short period, a greater level of arousal could be more desired (Perkins et al., 2001). Another approach is the reversal theory by Apter (1989, as cited in Turner & Jones, 2018). The theory puts focus on the subjective experience of arousal. Perkins et al. (2001) studied two different states of arousal grounded in

reversal theory, an anxious form and one characterised by excitement. Both states led to an increase in physical performance compared to a neutral state. There was no difference in physiological activation between the two states of arousal. The ones excited however, had an even greater increase in physical strength exertion. They conclude that a positive emotional tone matters for physical performance. Affective states appear to play a role in sport performance that involves more than just arousal.

Emotions have also been linked to personality within research (Hiebler-Ragger et al., 2018). Specific personality traits could be important for understanding the relationship between affective states and performance. Extraversion, a trait encompassing qualities such as sociability and assertiveness (Lucas & Diener, 2001), has been shown to moderate the relationship between anger and strength performance (Woodman et al., 2009). Personality can be viewed as qualities within an individual that orientate their thoughts, affective states, and behaviour (Karterud et al., 2014). A popular model used to understand and operationalize personality is the five-factor model, which consists of five different dimensions (McCrae & Costa, 2008). These are extraversion, neuroticism, openness, consciousness, and agreeableness. Among these personality dimensions, neuroticism has been found to positively correlate to trait-anger (Zajenkowski & Gignac, 2018). The term neuroticism was first introduced by Hans Eysenck (1947, as cited in Sauer-Zavala & Barlow, 2021). Neuroticism can be understood as a tendency to experience negative emotions (Sauer-Zavala & Barlow, 2021).

Illustrating the role of affective states in sports could have preparatory implications and could highlight areas of improvement for sport practitioners. It would support the use of affect-based psychological interventions for athletes who are disconnected from certain feelings or emotions and thus can potentially improve performance and well-being. There are previous studies done on how affective states influence physical strength (e.g., Davis et al., 2010; Giles et al., 2020; Perkins et al., 2001; Rathschlag & Memmert, 2013; Woodman et al., 2009). Altogether the field is limited and not fully understood. Not all affective states have been investigated, leaving questions on for example the role of the emotion shame. Potential interactions with personality have also been limited to extraversion, where research has shown that extraverts had a higher increase in strength when angry compared to introverts (Woodman et al., 2009). There is still little knowledge on individual differences on the relationship between affective states and strength. By including multiple affective states, personality traits and dividing participants based on how they

relate to anger, these individual differences could potentially be better understood. This would offer guidance on who may benefit from an affect-based intervention.

The primary purpose of this thesis was to further investigate the role of affective states on strength performance. That is, whether being connected to emotions influences physical performance. The following research question was answered: Will an increased activation of anger lead to a greater maximal physical performance compared to a more neutral state? In addition, data on other affective states was collected and analysed. How personality, gender and how participants relate to anger was also investigated.

Method

Participants

32 individuals (F = 19, M = 13, age 19-39 years, *M* = 24 years) were included in the study. All participants were active students at Umea University attending different courses and programs. Method of recruitment consisted of a convenience selection from this university. Inclusion criteria were fluency in the Swedish language and an age of at least 18. Exclusion criteria consisted of a performance on the hand dynamometer above the instrument's capacity (90 kg).

Basing the sample size on guidelines derived from nomograms, a requirement of 30 participants is deemed enough in respect to power (1-β = 0.8), effect size (*ES* = 1.0) and alpha value (α = .05) (Serdar et al., 2021). For secondary analyses a greater sample size would be preferred.

Instruments and Materials

Grip strength

Grip strength is the primary outcome measurement, defined as an individual’s capacity to squeeze the Saehan hydraulic hand dynamometer. This will represent maximal physical strength. The use of hand dynamometers is common for testing maximal strength exertion. Hand dynamometers of different models have shown excellent validity and reliability for measuring hand strength (Huang et al., 2022; Shechtman et al., 2005).

Affect Rating scales

To measure participant's affective response a simple continuum rating scale was developed, and pilot tested. The scales were based on Tomkins' affect theory and had eight different continuum-scales. The pilot study indicated that this instrument could measure different affective states, especially regarding anger, the state of greatest interest. This scale was constructed, instead of an already established scale, to investigate all of Tomkins' basal affective states in a time efficient way. Using for example Positive and Negative Affect Schedule (Watson et al., 1988) would only allow research on positive and negative affective states.

Each continuum scale is a ten centimetres long line and has an anchor-word located at the lowest point, in the middle and at the scale's maximum meant to offer guidance. These words began with the Swedish translation of minimal, moderate, or maximal and were then followed by a word to describe the affective state. These words were different to illustrate the intensity of each state. Anger as an example had a Swedish translation of the anchor-words minimal frustration, moderate anger, and maximal rage. Participants marked their rating with an x anywhere on the line in accordance with their current affective state. See appendix A to view these continuum-scales.

Questionnaires

To measure the big five personality traits a Swedish version of the questionnaire known as Big Five Inventory (BFI) was used. The BFI is a 44-item questionnaire used to measure an individual's openness, conscientiousness, extraversion, agreeableness, and neuroticism (John et al., 1991). The Swedish version of BFI has been deemed a trustworthy tool in research with good reliability and expected validity (Zakrisson, 2010).

To identify misleading data points, participants rated their current stress level and how well rested they were. Participants were asked to choose one of five statements that mostly corresponded to their current stress level and how rested they felt. See appendix B to view this questionnaire.

Two questions used to investigate the participants' attitude towards anger were also included in the study. The purpose of these two questions was to identify individual differences that may influence the relationship between affective states and strength. One is a seven-point Likert scale (1 = not at all, 7 = completely) asking them whether it is okay for the participant to

express anger. The second question was used to identify where the participant normally directed their anger, by a four-grade scale ranging from inwards to outwards. See appendix C to view this questionnaire.

Interventions

Two different interventions with the purpose to induce affective states were used in this study. A puzzle titled Intervention-A (I-A) and a guided, anger focused visualisation titled Intervention-B (I-B). Both interventions had shown to induce affective states during the pilot study. I-A and I-B both led to an activation of anger while I-A also induced a noticeable degree of shame for the pilot study participants.

Intervention A. The puzzle was the Cotuma Jigsaw Wave Puzzle 7 by Yuu Asaka. A seven-piece puzzle graded at level nine out of ten on a difficulty scale on the websites Amazon and Puzzle Master Inc. Participants were given this puzzle disguised as a cognitive test used to determine logical intelligence. The examinee was given four minutes to complete the puzzle under a false pretence of it usually being completed within two to four minutes. A noisy egg timer was placed next to the puzzle while the examiner gave verbal reminders to the examinee of how much time was left. The time limit given to the participants increased from two to four minutes after the pilot study. This test was presented as a cognitive test to create internal pressure to perform. Further amplified by giving an incorrect comparison point of how others usually perform. This in turn gave rise to frustration when the participant was unable to complete the puzzle within the given time frame. The reminders of time by the mechanical noise of the clock and verbal mentions were also meant to increase their internal pressure and thus further induce affective states. Another reason for disguising the puzzle as a cognitive test was to threaten the participants' self-esteem. Given that the sample are students, there is peer pressure to be competent, the prevalence of such pressure varies however across different schools and programmes (Bursztyn et al., 2019). The relevance of this pressure for the current sample was unknown. As the participant approached the time limit during their attempt at the puzzle, it was assumed that shame would begin to increase. Seeing this was the case during the pilot study, the puzzle could be used to see how shame might influence strength exertion.

Intervention B. The visualisation exercise consisted of two parts. Firstly, the participant was asked to identify a situation within their memory in which they felt anger. Secondly, they

listened to a pre-recorded audio file that built upon their identified situation. Self-inducing emotional states have been used in earlier research by Ratschlag and Memmert (2013). These were invoked by recollecting a specific memory in which the subjects felt the sought after emotional state.

At the beginning of each session the participant partakes in a short, guided visualisation audio file with a dual purpose. It served both as an introduction to guided visualisation and as a neutraliser to stabilise their affective state.

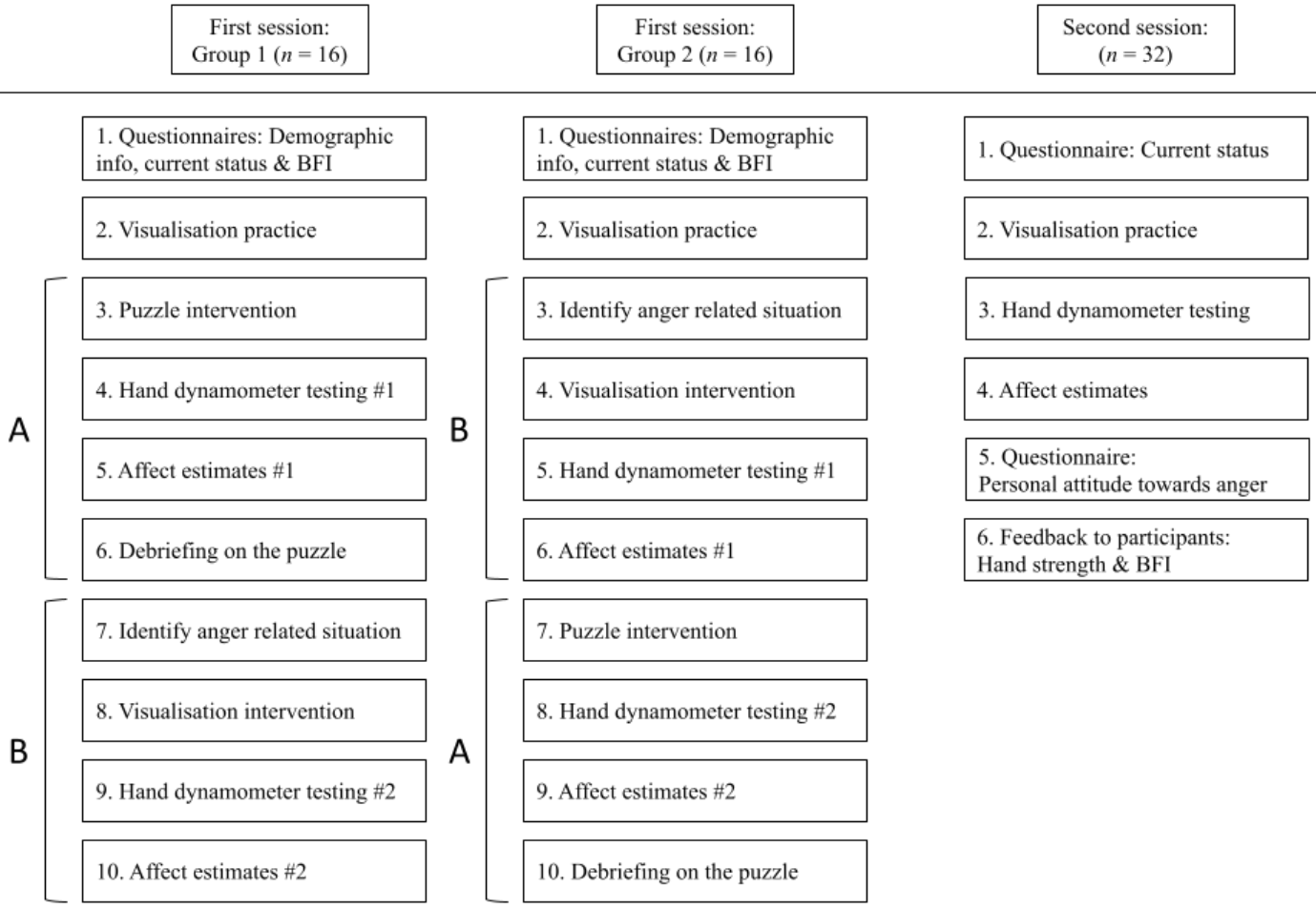
Procedure

Potential participants were informed orally and in writing about the study. This included the purpose of the study, who the researchers were and a brief overview about the procedure. The possibility to ask questions was given. Potential participants were also informed about their right to at any time decline their participation and that their results would be anonymised. To ensure anonymity, all data was coded, and all analyses were done on a group level. All gathered material would later be destroyed once the study was complete. If they were willing to partake in the study, a date for their participation was set up. During the first meeting a form of consent was signed, and the participants were offered their own copy. After the initial meeting a date for the second meeting was set up. These efforts to inform the participants were to ensure the ethics of information, anonymity, and participants self-determination. The ethical guidelines were further ensured with the written consent, containing the same information as given previously.

Participants were randomly assigned to one of two groups (See figure 1). Group 1 was given Intervention - A (I-A) first while group 2 was given Intervention - B (I-B) first. Each group then received the other intervention. This divide was done to account for any carryover effects e.g., lingering affective states and exhaustion, between the two interventions. The two interventions used are forms of ER in which the participant is expected to experience increased activation of affect. One through visualisation and another by attempting to complete a puzzle.

Figure 1

Overview for the procedure of each session.



Note. Both group 1 and group 2 took part in the second session.

The first session was initiated, regardless of group, by filling out several papers, namely a consent form, demographic info, current level of stress and how well rested they were. They were then also given the personality test BFI. These papers took approximately a total of 15 minutes to present and fill out. This was then followed by a visualisation practice that familiarised the participant with guided visualisation and brought their affective state closer to a baseline. After this they received either I-A or I-B and later, during the same session, partook in the intervention not yet received. Before moving to the next intervention, the participant performed a grip strength test with the hand dynamometer. This testing was placed as close to the interventions as possible, motivated by maximising the interventions effect at the time of testing. They were instructed to test their grip strength twice during the first session, once after each intervention. After each hand

dynamometer testing, the participants rated their current affective states. This rating was placed closely after, while changes in affective states were still felt or at least easier to remember.

During I-A, participants were first introduced to the puzzle. They were then given the puzzle along with a noisy egg clock and began their attempt at solving it. After performing at the hand dynamometer and estimating affective states, they were given a debriefing on the puzzle. This was done to reduce carryover effects from this intervention. During the debriefing, the participants were told that the puzzle was not an intelligence test and that the information about most people solving it in 2 minutes was a lie. I-B began by having the participant identify a situation that made them angry. They then listened to an audio file with headphones that built upon this situation through guided visualisation. Each intervention was roughly ten minutes long, including testing and estimates.

The control session, appointed as the second session, was the same for both groups. Placing the control session second for all participants would leave a potential practice effect. With respect to an excellent test-retest reliability (Karagiannis et al., 2020; Savva et al., 2014) two prior attempts were seen as unlikely to influence the control condition. The risk was also deemed necessary due to practical reasons related to attracting participants and having them return for the second session by minimising the time of the second session. It was also easier and more efficient for the test leader's ability to plan and book each session with minimal time waste.

All collected material was coded by a number instead of a name to ensure the participant’s integrity. A keycode was made possible from the form of consent in which they filled in personal data such as name. This later allowed for giving participant’s their compiled BFI results and grip strength measurements if requested. All BFI ratings were handled while coded. If the test leaders were to take notice and connect a specific participant’s result these were under oath of secrecy.

Data analysis

The data were analysed using IBM SPSS statistics version 29. Paired sample t-tests were used to compare the groups between different interventions and simple linear regressions were used to investigate correlations and statistically significant models between different items. Although not preferred, only simple instead of multiple linear regressions were used due to a limited number of participants. No outliers in the data were found. Visual inspection, skewness

and kurtosis indicated the data to be normally distributed and was deemed as parametric data. An alpha level of .05 was used for all statistical tests.

Several additional variables were created. All 8 affective variables were compiled into a new variable titled Average State of Affect (ASA). This was done by adding all states together and then dividing the sum by the number of addends. Variables on difference between grip strength, anger, and shame at different times were also computed.

The data was also analysed after being divided into subgroups. Four groups were formed with the two questions in appendix C. Two of which formed by the question if it was okay for them to show anger and the other two by the question where the participants direct their anger. Participant's that believed it was less okay for them to show anger (responses 1-4); Participant's that believed it was more okay for them to show anger (responses 5-7); Participant's that primarily directed anger inwards (responses 1-2); Participant's that primarily directed anger outward (responses 3-4).

Correlations used were Pearson's r and were classified as either small ($.30 > r \geq .10$), moderate ($.50 > r \geq .30$) or large ($r \geq .50$). Effect sizes used were Cohen's d and were classified as either small ($.50 > d \geq .20$), moderate ($.80 > d \geq .50$), large ($1.30 > d \geq .80$) or very large ($d \geq 1.30$).

Results

Grip strength differences

The two sessions resulted in three different grip strength measurements. This sample (N = 32) had its highest mean performance during the control condition (M = 38.5 kg, SD = 11.1), followed by I-B (M = 37.8 kg, SD = 10.7) and was lowest at I-A (M = 36.5 kg, SD = 9.70). The differences between these means were analysed with a paired sample t-test (See table 1). I-A showed a statistically significant difference, t (31) = -2.17, p = .04, in grip strength compared to the control, where I-A gave a lower mean performance of 2.00 kg (SD = 5.21) 95% CI [-3.88, -.12], resulting in a small effect size (d = -.38). The other differences were not statistically significant.

Table 1

Grip strength differences between condition I-A, I-B, and control

				95% CI				
	M	*SD*	*SE*	*LL*	*UL*	*t* (31)	*p*	Cohen's *d*
I-A x Control	-2.00	5.20	0.92	-3.88	-0.12	-2.17	.04	-.38
I-B x Control	-0.69	4.12	0.73	-2.17	0.80	-0.94	.35	-.17
I-A x I-B	-1.31	5.57	0.98	-3.32	0.70	-1.33	.19	-.24

Note. N = 32. I-A = Intervention - A; I-B = Intervention - B; CI = confidence interval; LL = lower limit; UL = upper limit.

Differences in affective states

The two interventions lead to an increase in multiple affective states compared to the control (See table 2). Anger estimates were higher during both I-A (M = 41.8) and B (M = 54.5) compared to the control (M = 5.81). Shame was also higher for both I-A (M = 42.8) and I-B (M = 17.0) compared to the control (M = 5.16). There was a statistically significant positive correlation (r = .71, p < .001) between anger and shame during I-A, while I-B showed no correlation (r = .05, p = .80) between anger and shame.

Table 2

Descriptive statistics for different affect estimates during condition I-A, I-B, and control

		Intervention - A		Intervention - B		Control	
	N	*M*	*SD*	*M*	*SD*	*M*	*SD*
ASA	32	34.3	14.1	31.6	11.7	18.1	7.40
Anger	32	41.8	21.8	54.5	19.3	5.81	8.37
Shame	32	42.8	26.1	17.0	17.1	5.16	6.49
Disgust / Dismell	32	30.3	26.2	45.8	31.4	5.81	9.85
Interest	32	49.1	27.2	36.6	28.0	46.6	21.5
Distress	32	18.4	23,5	24.6	24.2	5.75	8.62
Fear	32	18.8	22.7	17.8	20.8	8.34	10.2
Enjoyment	32	27.8	19.7	27.4	21.2	51.2	18.6
Surprise	32	44.8	22.5	29.2	24.5	16.4	19.4

Note. Values range from 0-100, where 0 represents lack of an affective state and 100 represents maximal activity of an affective state. ASA = Average state of affect.

Paired sample t-tests showed statistically significant differences between the three trials on both anger and shame (See table 3). I-A showed a statistically significant difference, t (31) = 9.15, $p < .001$, in anger compared to the control, where I-A gave a higher mean estimate value of 35.9 (*SD* = 22.2), 95% CI [27.9, 43.9], resulting in a very large effect size (d = 1.62). I-B also showed a statistically significant difference, t (31) = 13.0, $p < .001$, in anger compared to the control, where I-B gave a higher mean estimate value of 48.7 (*SD* = 21.2), 95% CI [41.1, 56.3], resulting in a very large effect size (d = 2.30). I-A showed a statistically significant difference t (31) = 4.76, $p < .001$, in shame compared to I-B, where I-A gave a higher mean estimate value of 25.8 (*SD* = 30.6), 95% CI [14.7, 36.8], resulting in a large effect size (d = .84).

Table 3

Anger and shame differences between condition I-A, I-B, and control

			95% CI				
	M	*SD*	*LL*	*UL*	*t* (31)	*p*	Cohen's *d*
Anger: I-A x Control	35.9	22.2	27.9	43.9	9.15	<.001	1.62
Anger: I-B x Control	48.7	21.2	41.1	56.3	13.0	<.001	2.30
Anger: I-A x I-B	12.8	27.5	-22.7	-2.85	-2.63	.01	-.46
Shame: I-A x Control	37.6	26.2	28.2	47.1	8.12	<.001	1.44
Shame: I-B x Control	11.8	14.3	6.69	17.0	4.69	<.001	.83
Shame: I-A x I-B	25.8	30.6	14.7	36.8	4.76	<.001	.84

Note. $N = 32$. I-A = Intervention-A; I-B = Intervention-B; CI = confidence interval; LL = lower limit; UL = upper limit.

Correlations and regressions between affective states and grip strength

Three statistically significant moderate to large negative correlations appeared between affective states and grip strength during I-B (See table 4). Simple linear regression offered statistically significant models for each. One statistically significant model, F (1, 30) = 7.00, p = 0.01, indicated that 19% (r^2 = .19) of the variation in grip strength during I-B could be explained by ASA. The model gave a negative correlation (B = -.44). Another model, F (1, 30) = 8.78, p = 0.006, indicated that 23% (r^2 = .23) of the variation in grip strength during I-B could be explained by disgust. The model gave a negative correlation (B = -.48). The third model, F (1, 30) = 10.5, p = 0.003, indicated that 26% (r^2 = .26) of the variation in grip strength during I-B could be explained by interest. The model gave a negative correlation (B = -.51). Interest and disgust had no statistically significant correlation between one another during I-B (r = .06, p = .75). Enjoyment showed a small positive correlation (r = .27) to grip strength that was close to statistically significant (p = .07) during I-B. The control showed a statistically significant negative correlation to grip strength for disgust (r = -. 30, p = .05) and surprise (r = -. 38, p = .02).

Table 4

Correlations between affect and grip strength during condition I-A, I-B, and control

		I-A		I-B		Control	
	N	*r*	*p*	*r*	*p*	*r*	*p*
ASA	32	-.10	.30	-.44	.006	-.27	.07
Anger	32	-.18	.17	-.16	.20	-.12	.26
Shame	32	-.27	.06	-.13	.25	-.09	.31
Disgust / Dismell	32	-.04	.41	-.48	.003	-.30	.05
Interest	32	-.12	-.26	-.51	.001	-.19	.15
Distress	32	.22	.12	-.14	.22	-.09	.32
Fear	32	-.08	.33	-.21	.12	.04	.43
Enjoyment	32	.08	.33	.27	.07	.03	.43
Surprise	32	-.02	.46	-.16	.19	-.38	.02

Note. I-A = Intervention-A; I-B = Intervention-B; ASA = Average state of affect.

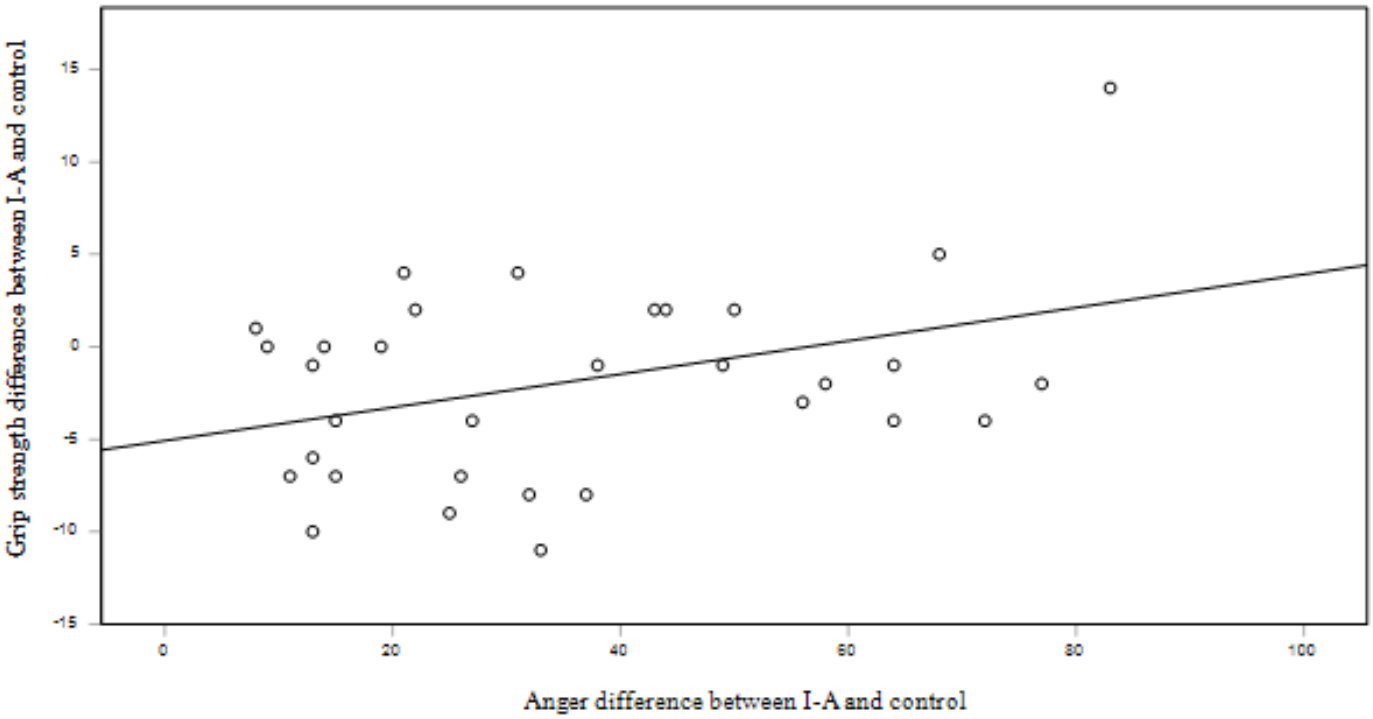
Comparisons between male and females regarding interest showed that for males (n = 13), interest had a statistically significant negative correlation (r = -.80, p <.001,) with grip strength during I-B but not for females. Females (n = 19) however; showed a statistically significant negative correlation (r = -.53, p = .01) between shame and grip strength during I-B, whereas men did not. Surprise and grip strength had statically significant negative correlations (r = -.43, p = .03) during I-B for females but not for males. No other statically significant differences were found between males and females. Mean differences in activation of interest, shame, and surprise, showed no statistical significance between males and females during I-B.

Analyses using the difference between an intervention and the control on both affective states and grip strength, provided additional results. A simple linear regression gave a statistically significant model, F (1, 30) = 4.62, p = .04, where 13% (r^2 = .13) of the variation, regarding difference in grip strength between I-A and control, could be explained by the difference in anger between I-A and control. Participants' difference in grip strength between I-A and control could be predicted as -5.08 + 0.09 (See figure 2). For each value that I-A is higher in anger than control, I-A increased their grip strength by 0.09 kg compared to the control. The model gave a positive

moderate correlation (*B* = .37). Other differences on shame or anger with grip strength warranted no statistically significant models.

Figure 2

Scatterplot for rated anger and grip strength differences between condition I-A and control



Note. The X-axis shows the differences in anger between I-A and the control gathered from estimates within the range of 0 to 100. On the scatterplot, a 0 represents no difference and 60 represents an estimate of 60 values higher during I-A compared to control condition. The Y-axis shows the difference in kilograms in grip strength between I-A and the control condition. Negative values represent a weaker performance during I-A compared to the control condition. I-A = Intervention-A; I-B = Intervention-B.

Dividing the data based on how the individual relates to anger offered two statistically significant correlations (See table 5). Simple linear regression offered no statistically significant models, however. Participants that felt more okay to express anger (*n* = 15) had a statistically significant negative correlation (*r* = -.50, *p* = .03) between shame and grip strength during I-A. Those that felt less okay to express anger (*n* = 17) had no statistically significant correlation (*r* = -.16, *p* = .26) between shame and grip strength during I-A. Participants that directed anger mostly

inward (n = 15) had a statistically significant negative correlation (r = -. 47, p = .03) between shame and grip strength during I-B. Those that directed anger mostly outward (n = 17) showed instead a positive correlation that, although close, was not statistically significant (r = .39, p = .08) between shame and grip strength during I-B.

Table 5

Correlations for anger specific subgroups, between grip strength and the states of anger and shame, during condition I-A and I-B

		Anger and grip strength				Shame and grip strength			
		I-A		I-B		I-A		I-B	
	n	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Anger not okay	17	-.12	.33	-.20	.28	-.16	.26	.18	.25
Anger okay	15	-.33	.12	-.11	.35	-.50	.03	-.38	.08
Anger in	15	-.28	.16	.06	.41	-.29	.15	-.47	.03
Anger out	17	-.01	.48	-.38	.06	-.28	.14	.39	.08

Note. Anger not okay felt less okay to express anger while Anger okay felt more okay to do so. Anger in primarily directed anger inward while Anger out primarily directed it outward. I-A = Intervention-A; I-B = Intervention-B.

No analyses on interactions between personality and affect regarding grip strength were made due to the number of participants. Instead, analyses on personality were limited to correlations between affective states and neuroticism. No statistically significant correlations were identified between neuroticism and anger during either I-A (r = .08, p = .32) or I-B (r = -.06, p = .38). A non-statistically significant positive correlation was identified between neuroticism and shame during I-A (r = .23, p = .10). No statistically significant correlation existed between neuroticism and shame during I-B (r = -.02, p = .45).

Discussion

The results from this study showed that both I-A (puzzle intervention) and I-B (anger focused visualisation intervention) lead to a statistically increased state of anger compared to the control condition. Despite this, and contrary to previous findings (e.g., Davis et al., 2010; Rathschlag & Memmert, 2013; Woodman et al., 2009), the participants were the strongest during the control, being statistically weaker during I-A, compared to the control (See table 1). Anger was not the only affective state that was different during the interventions and control however (See table 2).

Two affective states (disgust and interest) showed statistically significant negative correlations to grip strength during I-B for the entire sample. As disgust also showed statistically significant correlation to grip strength during the control condition, it seemed to have at most been amplified when combined with an anger focused visualisation. Experiencing interest while doing an anger focused visualisation appears to hinder strength output, but only for males. Experiencing shame and surprise during the visualisation only showed statistically significant negative correlation to grip strength for females. These gender differences could be related to coincidence. Another explanation is qualitative differences on a subgroup level during the guided visualisation. Data from a meta-analysis (Su et al., 2009) has suggested a gender difference, where males show greater interest towards things while females show greater interest towards people. Males may thus be more focused on the result of an unjust interaction, e.g., losing or being denied something of interest, placing the affective state of interest in greater focus. Shame has been described to serve a function of social critique (Frank & Wilson, 2020). It might have been the case that women more often focused on the act of an unjust interaction, i.e., individual's behaviour, placing an aspect of shame in greater focus. To ensure the participants integrity, they were requested to not disclose their chosen memory. This was done on ethical grounds but precludes drawing conclusions on the type and character of different individuals' memories. Despite no statistical difference in degree of interest, shame, or surprise, between males and females, an increased focus might have meant greater inner conflict with the state of anger. Neither of these three affective states were expected to have a focus during the guided visualisation. Depending on how these states are expressed and related to, they may send different signals and information to the body compared to for example

anger. This all may result in an inner conflict that inhibits the body's ability to produce maximal strength output. A concept of conflicting state of affects is continued in a later section.

Enjoyment, during I-B, was the only affective state that, although non-statistically significant, had a positive correlation to grip strength. A larger sample may have given a significant correlation and would be in line with previous research on feelings of happiness and strength output (e.g., Rathschlag & Memmert, 2013; Woodman et al., 2009). When the control was included by using variables representing differences between an intervention and the control, a different result appeared. Higher anger during I-A increased strength output during I-A, relative to the control, despite I-A showing a lower mean grip strength. This increase in strength does align with previous research on the relationship between anger and strength, anger does indeed make one stronger.

A reason as to why the grip strength performance was weakest after getting upset at a puzzle (Intervention - A) cannot be confirmed. There are different potential explanations for this result. One hypothesis is that the introductory visualisation exercise meant to bring each participant to a baseline had a positive impact on strength output. This positive impact could have been negated by I-A. Another hypothesis is negative variables for strength output during both interventions, primarily during I-A. Perhaps both I-A and I-B even had positive variables that would improve strength performance but were outweighed by negative variables.

The two interventions differentiated most in the level of shame, in which I-A gave higher estimates at a large effect size. This difference in shame was expected and can be attributed to elements of comparison, failure, and sense of incompetence. During the instructions for I-A the participants were falsely told this puzzle would measure their intelligence and of how fast others usually complete it. They then get to experience the inability to complete this deceiving puzzle. Lazarus (2000) believed anger that is channelled through self-blame, will be bad for performance. The increased shame during I-A might represent self-blame. This could explain why the mean performance was weakest during I-A. Data from dividing this study's sample gives further indication that anger through self-blame can reduce strength performance. Directing anger inward and feeling shame during I-B correlated moderately with a worse grip strength performance. Directing anger outward, although only close to statistically significant, showed a moderate positive correlation between shame and grip strength. It is possible that anger through self-blame primarily occurred for those that directed anger inward. Shame might represent to what degree

self-blame was done during the visualisation. Participants who directed anger outward presumably externalised their anger upon the subject in their visualisation. For these individuals an amount of shame might have fuelled their anger even further instead and did not represent self-blame. This result is supported by prior research on increased strength exertion derived from anger, where the increase in strength became suppressed when directing anger towards the self (Davis et al., 2010). Deceiving participants on the true nature of the puzzle was deemed acceptable regarding ethics. All participants were debriefed after attempting the puzzle and they were informed that different affective states would be felt prior to giving their consent. All participants were also offered a calming breathing exercise afterwards if needed, which non did.

The source of shame has been described as the inhibition of a positive affective state (Frank & Wilson, 2020). The increased shame therefore suggests that some of the participants' affective states are inhibited during I-A. A broader concept of internal conflict as a negative variable would help explain this study's results. Internal conflicts that take the form of inhibited or conflicting affective states, leading to a reduced strength performance. There were moderate to large gender specific negative correlations between affective states and grip strength during the anger focused guided visualisation. These states, as previously mentioned, could have conflicted with other states such as anger. Having feelings of shame during I-A showed a large negative correlation to grip strength for those that felt more okay to express anger. These individuals might be less accustomed to a combination of shame and anger, resulting in a greater inner conflict when shame does increase.

No significant correlations were found between neuroticism and anger or shame. Given a larger sample, being neurotic may correlate to greater levels of shame during I-A. The data gave no indications on a relationship between neuroticism and anger.

In conclusion, affective states are relevant for strength output, but the specifics of which states and how they influence strength remains unclear. Both a puzzle and a visualisation can induce affective states. Anger, under the proper circumstances, appear to increase strength output. These circumstances are still not fully understood but may involve subjective qualities within the individual and avoiding negative influences when increasing anger. It is possible that anger through self-blame suppresses this increase in strength. Based on negative correlations to certain affective states, it could also be hypothesised that inhibited and conflicting states of affect are a

hindrance to strength performance. If the hypotheses on self-blame or affect-based internal conflicts are true, it would support affect-based interventions for strength-based athletes.

Weaknesses and limitations

The number of participants (N = 32) limited which data analyses could be made and meant that statistical significance was harder to achieve with weaker correlations and effect sizes. Upon dividing the group based on gender and how participants relate to anger this became even more relevant. A greater number of participants would also reduce the impact of one limitation regarding grip strength testing. When using the hand dynamometer, participants performed only one attempt per trial. This was done to mitigate physical exhaustion between the two interventions, but one attempt also allowed for more random variance. To answer this, participants were allowed to inspect the instrument and find a comfortable grip at the start of the session. Even with this effort, there is still a possibility of getting a bad grip which can yield a weaker measurement on maximal grip strength.

This study used a convenience sample of students, which can put the applicability toward athletes into question. The common denominator between this sample and athletes is that both are human beings with the same internal biological processes. It could therefore be reasoned that this study's results are applicable to athletes. The choice of instrument, hand dynamometer, has been used in previous studies (e.g., Perkins et al., 2001; Rathschlag & Memmert, 2013). But how well this represents other forms of maximal strength output is unclear. Furthermore, the experiment was carried out in a laboratory. All these factors influence how well the results can be generalised in the real world, i.e., ecological validity.

Another weakness is the possibility of a carryover effect in affective states between the two interventions. This was primarily dealt with by making two groups, one that began with I-A and another that began with I-B. It was also managed by placing the debriefing of the puzzle at the end of I-A. Despite these efforts, a carryover effect can still influence estimates on affective states.

There is a potential training effect, but this risk was deemed minimal. Each participant performed a total of two attempts during the first session before the second session. There is still a possibility that a training effect through neurological adaptation existed and improved performance during the control condition.

The two questions on how an individual relates to anger were created specifically for this study and have not been validated. These questions were limited to only divide the group, but these subgroups could have possibly been more accurate. Even if the questions were pilot tested, there are more extensive ways to gain a more accurate response. Using for example a questionnaire like State-Trait Anger Expression Inventory 2, tendencies of where a participant directs their anger could potentially be better identified. To gain the information and data that was needed, it was deemed most practical to construct this study's questionnaires by hand. It made sure each participant had to spend less time answering questions. It also allowed for all required information to be collected, identified questionnaires that were already constructed could not provide this. This was the case with the study's continuum-scales meant to measure activation of affect. A better alternative could simply not be found. However, one can still question the accuracy of subjectively reported affective states.

Future research

Due to the limited sample (N = 32) the use of multiple linear regressions was not deemed possible. Instead, several simple linear regressions were used, which increases the probability of type-1 errors. The use of multiple linear regressions would also showcase potential interaction effects between different variables. Future studies with larger samples may also find significant results for smaller correlations and effect sizes. Larger studies could also include physiologically measured data to get a more accurate level of how well rested participants were.

It would also be interesting if future research looked further into self-blame and investigated affect-based internal conflicts' influence on strength performance. Research on affective states and how they influence physical performance has value. Findings from future studies may enhance performance for both athletes as well as the ordinary exerciser. The world of sports serves society a function. A greater strength performance can serve a function for the individual. Specifics on affective states that exist during exercise may also be relevant for health reasons. Maximising what you get out of each training for both health and performance results. In a world where a stationary life becomes increasingly common, a link between affective states and athletic performance may have more societal worth than meets the eye.

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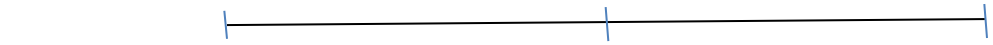
Appendix A

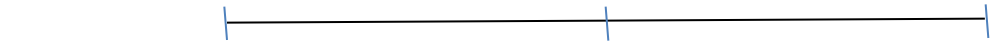
Continuum-scales for self-observed affect

Vrede



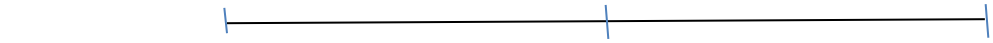
Minimal irritation **måttlig vrede** **Maximalt raseri**

Skam



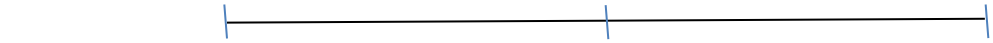
Minimalt ångrande **måttligt skamsen** **Maximal förnedring**

Avsmak/avsky



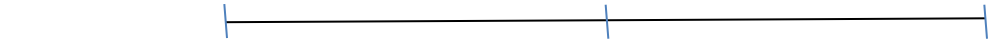
Minimal olust **måttlig avsky** **Maximalt äckel**

Intresse



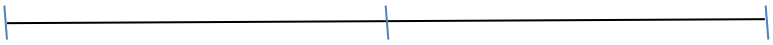
Minimal nyfikenhet **måttligt intresse** **Maximal entusiasm**

Sorg



Minimal ledsenhet **måttlig sorg** **Maximal Förtvivlan**

Rädsla



Minimal oro **måttlig rädsla** **Maximal panik**

Glädje

Minimal tillfredsställelse **måttlig glädje** **Maximal lycka**

Förvåning

Minimal häpenhet **måttlig förvåning** **Maximal chock**

Appendix B

Current state-form

Dagsform

Ringa in det alternativ som stämmer bäst överens med din nuvarande status:

***Hur utvilad jag är*:**

Jag känner mig inte alls utvilad

Jag känner mig mindre utvilad än vanligt

Jag känner mig som vanligt

Jag känner mig mer utvilad än vanligt

Jag känner mig mycket mer utvilad än vanligt

***Nuvarande stressnivå*:**

Jag känner mig inte alls stressad

Jag känner mig mindre stressad än vanligt

Jag känner mig som vanligt

Jag känner mig mer stressad än vanligt

Jag känner mig mycket mer stressad än vanligt

Appendix C

Attitude towards anger

Förhållning till vrede

Det är okej för mig att uttrycka vrede:

Inte alls 1 2 3 4 5 6 7 Helt och hållet

Ringa in det påstående som stämmer bäst överens med hur du brukar göra:

När jag blir arg:

Brukar jag rikta min ilska mot mig själv

Riktar mestadels ilskan mot mig själv

Riktar mestadels ilskan utåt

Brukar jag rikta ilskan mot andra