The Forecast of Victory: Mental Toughness as a Predictor of Future Tennis Success

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Abstract

Mental toughness is increasingly recognized as a critical psychological attribute influencing athletic performance across various sport disciplines. This study aimed to explore the predictive value of mental toughness on future tennis performance and investigate whether this relationship is mediated by cognitive anxiety. The sample consisted of 171 young Dutch tennis players (13.1 ± 2.1 years old). During the 2017-2018 tennis season, mental toughness and cognitive anxiety were assessed by the Mental Toughness Questionnaire-48 and Competitive State Anxiety Inventory-2, respectively. Tennis performance was operationalized using tennis ratings from the 2022-2023 season. Lower ratings represented better performance. The results indicated a significant negative correlation between mental toughness and future tennis rating. Additionally, regression analysis confirmed mental toughness as significant predictor of future tennis rating, accounting for 9.06% of variance when controlling for age. However, no significant effect was found for the mediator role of cognitive anxiety. Exploratory findings suggest the variance in future tennis rating is best explained by the subscales life control and confidence in ability. These findings underscore the importance of mental toughness in predicting future tennis success. The study contributes to the understanding of the effects of mental toughness and has implication for talent selection and psychological skills training among athletes.

Keywords: mental toughness, sports performance, cognitive anxiety, tennis, Dutch tennis players.

The Forecast of Victory: Mental Toughness as a Predictor of Future Tennis Success

In 1996, Richard Krajicek made history by securing the Wimbledon title, becoming the only Dutch player to achieve a Grand Slam singles victory. More than a quarter century later, the Netherlands eagerly await another Grand Slam title. Concurrently, the Royal Dutch Lawn Tennis Association (KNLTB) strives to establish a permanent presence among the world's top tennis tournaments. To become a professional, the physical, technical, tactical, and psychological tennis-specific performance-related components must be developed well (MacCurdy, 2006). In progressing towards the elite level in every sport, the latter has been shown to be of great importance (McNamara et al., 2010). One psychological concept extensively explored in the literature is mental toughness (Gucciardi et al., 2015), which can be considered a multidimensional construct encompassing, among others, the ability to control emotion, positively appraise challenges, and maintaining confidence under pressure (Clough et al., 2002). The concept has been noted for its direct positive influence on sports performance in several different sports (Hsieh et al., 2023). However, research has yet to investigate whether mental toughness can predict future performance, specifically in tennis. The current study aims to address this gap and explore whether cognitive anxiety mediates this potential relationship. Practically, we hope to contribute to the ambitions of the KNLTB, by informing their talent selection procedures.

What is Mental Toughness?

Mental Toughness (MT) was first coined within applied sports psychology by Loehr (1982). Early work lacked scientific rigor (Crust, 2007) and as a result "virtually any desirable positive psychological characteristic associated with sporting success had been labeled as MT" (Jones et al., 2002). Since then, conceptualization has progressed, despite a universal definition still being absent (Tibbert et al., 2015). Current conceptualizations see MT as an umbrella term for various attributes that facilitate resilience, confidence, and success across a

range of achievement contexts (Dagnall et al., 2019). Harmison (2013) suggests MT to be both state-like, as it varies with situational demands (Connaughton et al., 2008; Slack et al., 2015), and trait like, due to its partial heritability (Hornsburgh et al., 2009; Veselka et al., 2010). Supporting this view, Gucciardi and colleagues (2015) found variability in MT to be both intraindividual (56%) and interindividual (44%). MT is therefore both an attribute (trait-like) one can possess, and a skill (state-like) one can utilize.

Clough and colleagues (2002) developed the most frequently used conceptualization of MT. Their 6Cs model of MT is based on theoretical research of the hardiness concept (Kobasa, 1979; Kobasa et al., 1982) and adapted to fit the sport-specific context. MT is defined through the following factors: emotional control, life control, commitment, challenge, confidence in abilities, and interpersonal confidence. Emotional control is defined as the ability to manage emotions in stressful situations; life control denotes the belief that one can influence what happens in their life; commitment reflects the tendency to stay dedicated to tasks despite obstacles; challenge reflects the belief that change is an opportunity for growth rather than a threat; confidence in abilities reflects a strong belief in one's skills; and interpersonal confidence concerns confidence in social settings.

Mental Toughness and Athletic Performance

A meta-analysis by Hsieh and colleagues (2023) explored the relationship between mental toughness and athletic performance. Encompassing sixteen studies of moderate to high quality across several countries and sport disciplines, the authors reported an almost large general correlation of $r = 0.36$. Moreover, it identified several moderators influencing this relationship. Notably, adults showed a stronger correlation ($r = 0.41$) than adolescents did ($r = 0.20$), suggesting age as moderator. Different relationships between MT and type of sport were also found, with combat sports demonstrating the biggest correlation ($r = 0.73$), followed by endurance sports ($r = 0.32$), and ball sports ($r = 0.30$). These findings mark MT's

substantial correlation with sports performance, dependent upon various moderators.

Extending the discussion to tennis, Cowden (2016) reported evidence for the relationship between MT and sports performance. The study included 43 adolescent tennis players from South Africa competing at a national tournament, utilizing the Mental Toughness Inventory (MTI; Middleton et al., 2013) to measure MT and tennis ranking to operationalize tennis performance. A significant correlation between MT and ranking (r = -0.29) and MT and match outcome (r = 0.52) was found. Concluding mentally tough tennis players tend to achieve better rankings (i.e., ranked lower) and a slightly higher likelihood of emerging victorious. The study underscores the relevance of MT in tennis performance specifically. Other research has examined the same relationship (Morais & Gomes, 2019; Cowden et al., 2014). These studies found MT to be positively related to micro indices (e.g., first serve percentages and less double faults), but not significantly correlated to team ranking.

While the existing literature has mostly explored the cross-sectional relationship between MT and sports performance (Hsieh et al., 2023), there are compelling reasons to examine its predictive potential. Firstly, MT can be considered relatively stable, due to its trait-like qualities (Gucciardi et al., 2015; Hornsburgh et al., 2009; Veselka et al., 2010). MT is therefore expected not to vary wildly, which makes it suitable for measuring effects over time. Effects of high MT include an unshakeable self-belief, ability to rebound after failures, refusal to quit, and effective coping (Crust, 2007). As a result, mentally tough athletes should be more likely to achieve sustained success over time. To our knowledge, no study has examined the prospective effect of MT on sports performance. Through this novel study design, a gap in the literature could be filled. Practically, it could improve selection processes of sport organizations by providing evidence for the importance of MT.

The Role of Cognitive Anxiety

Stress has long been theorized to influence performance. This relationship was initially

conceptualized as an inverted-U shape (Yerkes & Dodson, 1908), with moderate amounts leading to optimal performance, while low and high amounts lead to inferior results. Despite being a foundational theory, many sport psychologists became dissatisfied with the 'overly simplistic' explanation and proposed new theories (McNally, 2002). In response, Martens and colleagues (1995) developed multidimensional anxiety theory. The theory suggests that competitive anxiety can be divided into cognitive (e.g., worry and negative thoughts) and somatic anxiety (e.g., physiological symptoms), which have a differential impact on performance. Somatic anxiety is theorized to adhere to the inverted-U shape, whilst cognitive anxiety is negatively linearly related to performance.

Moving back to MT, mentally tough athletes tend to experience lower stress levels (Kaiseler et al., 2009). Cowden and colleagues (2014) examined whether this extends to competitive tennis players. The author studied 351 competitive South African tennis players who competed to weeks prior to participation. The Sports Mental Toughness Questionnaire (Sheard et al., 2009) measured MT and the Sports Competition Anxiety Test (Martens, 1977) assessed stress levels. The results showed a significant negative correlation between stress MT (r = -0.44), implying that mentally tough tennis players experience less overall stress. In other research, Mojtahedi and colleagues (2023) examined whether MT could predict competitive anxiety, specifically somatic and cognitive anxiety. The authors included 194 combat sports athletes, measured MT using the MTQ10, a shortened version of the MTQ48 (Dagnall et al., 2019), and competitive anxiety using the revised Competitive State Anxiety Inventory-2 (Cox et al., 2003). Mentally tough athletes presented significantly lower levels of somatic (r = -0.29) and cognitive anxiety (r = -0.30). Thus, mentally tough combat sports athletes tend to experience less somatic and cognitive anxiety.

Cognitive anxiety has been theorized to be detrimental to sports performance (Martens et al., 1995). As far as we are aware, no research has been done whether cognitive anxiety is

detrimental to future sports performance also. Because cognitive anxiety is stable across competitions and over time (Martens et al., 1995), it seems a relatively stable trait and should be predictive of future performance also. Moreover, given that mentally tough tennis players are more likely to experience less overall stress (Cowden, 2014) and combat athletes high in MT tend to experience less cognitive anxiety (Mojtahedi et al., 2023), we also speculate that tennis players high in MT might also experience less cognitive anxiety. Thus, mentally tough athletes should experience less cognitive anxiety and therefore perform better in the future. Investigating this relationship could provide new information regarding potential mediators in the MT-sports performance relationship and provide evidence for the prospective effect of cognitive anxiety, specifically on tennis performance, which could underscore its importance for selection processes.

The Current Study

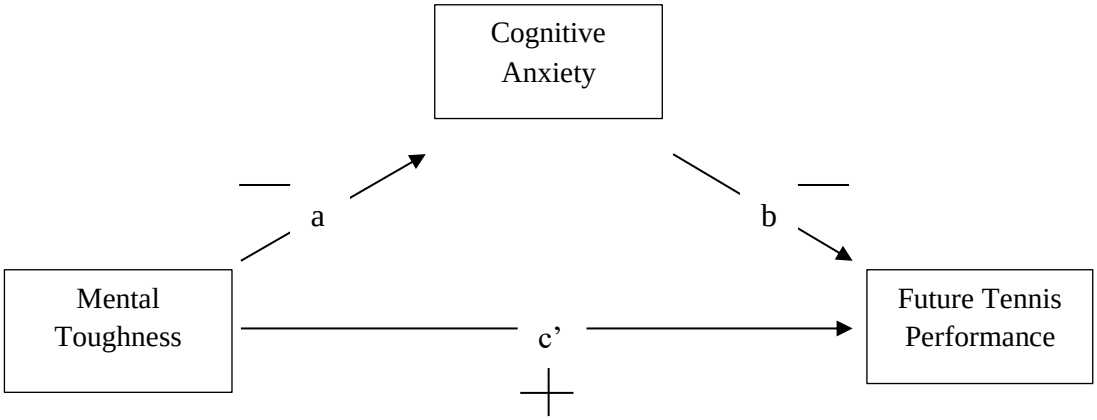
This paper aims to examine the relationship between MT and future tennis performance and whether this relationship is mediated by cognitive anxiety, as visualized in Figure 1. To our knowledge, existing studies have examined the effects of MT almost exclusively cross-sectionally. By adopting a novel study design, the study could provide new information and fill a gap in the literature. Practically, gaining insight into the importance of MT and cognitive anxiety on future tennis performance could be valuable for the selection processes of sport organizations. The following hypothesis were tested:

Hypothesis 1. Mental Toughness is a significant predictor of Future Tennis Performance.

Hypothesis 2. The relationship between Mental Toughness and Future Tennis Performance is mediated by Cognitive Anxiety.

Figure 1

The Mediation Model



Method

Participants

The sample was adapted from Kramer (2020), who selected talented tennis players from the training programs of the Dutch National Lawn Tennis Association (KNLTB) during the 2017-2018 tennis season. The players were asked to participate through their tennis academies. They were included in the sample when both parents and the players gave written consent. Their data would then be pseudonymized. Participation was voluntary, no compensation was given, and participants could terminate involvement at any point during the study. The current study only utilizes data from players who agreed to the reuse of their data for further research and whose ranking for the 2022-2023 season were available. This gave a final sample of 171 tennis players (boys n = 98; girls n = 73), ranging from 8.5 to 19.4 years old with a mean of 13.1 ± 2.1 (Table 1). The players were highly talented, as the fast majority (n = 163) of them were ranked in the top 200 of their respective birth year during the 2017-2018 tennis season. Ethical approval has been given by the faculty of Health and Social Studies at the HAN University of Applied Sciences, 17 March 2017, EACO 62.03/17.

Measures

The Mental Toughness Questionnaire-48

To measure Mental Toughness (MT), the Mental Toughness Questionnaire-48 (MTQ48) by Clough and colleagues (2002) was used. The questionnaire consists of 48 items measuring the following subscales: commitment; control (life and emotional); challenge; and confidence (in ability and interpersonal). These add up to a total mental toughness score, with a higher score indicating higher mental toughness. The participants were presented with statements (for example, "I usually find something to motivate me") and rate these on a five-point Likert scale (ranging from 1 = strongly disagree to 5 = strongly agree). The internal consistency in the sample was α = .83 and can be labeled as good (George & Mallery, 2005). A small difference in internal consistency was found compared to Clough & Strycharczyk (2012), reporting α = .91. Perry and colleagues (2013) indicate the MTQ48 to be a robust psychometric measure of MT.

Cognitive Anxiety

Cognitive anxiety was measured using the revised version of the Competitive Sport Anxiety Inventory-2 (CSAI-2R; Cox et al., 2003). The CSAI-2R includes the subscales cognitive anxiety, somatic anxiety, and self-confidence. The scale consists of 17 items, of which the 5 measure cognitive anxiety. Participants are presented statements (for example, "I was worried that I wouldn't do as well as I normally do") and asked in what capacity they agree them (1 = not at all; 4 = a lot). The average of the scores across the questions of the subscale are taken and multiplied by ten. Scores can vary between 10 and 40, with a higher score indicating more cognitive anxiety. In the current sample, internal consistency for cognitive anxiety was equal to α = .78 and seems acceptable, close to good (George & Mallery, 2005). This is a little lower than found by Terry & Munro (2008), reporting a Cronbach's alpha between .82 and .88.

Tennis Performance

To operationalize tennis performance, the Dynamic Playing Strength System (DSS) from the KNLTB was used. The rating represents the general level of play and can range from 9 (beginner) to 1 (professional), with 4 decimal places. In other words, lower ratings indicate better players. After each match rating is calculated, making it dynamic. Current rating is based on results achieved and number of matches played. Opponent rating influences points gained or lost. For example, winning from a higher rated players gives more points than winning from a lower rated player. These characteristics of the DSS make it a good approximation of tennis performance. The current study utilizes the end ratings of the players for the 2022-2023 tennis season.

Procedure

Data from the MTQ48 and CSAI-2R were adapted from Kramer (2020) and collected during the 2017-2018 season. Participants completed the questionnaires either before or after training in a silent room at the tennis center, taking about 15 minutes to fill in. The head researcher was present to give instructions. It was affirmed that wrong answers were not possible, and results would be processed anonymously, in the hope to minimize social desirability bias. The data from these questionnaires were coupled with the end season tennis ratings of the 2022-2023 tennis season, five years later. These ratings were taken from the website of the KNLTB for the corresponding players. Which player corresponded to which data was not known by the authors, only by the supervisor. In this was anonymity of the tennis players was secured. Since the study follows the same group of tennis players over time, a prospective study design is utilized. The relationship between mental toughness, as measured in the 2017-2018 season, and future tennis performance, as operationalized by tennis rating from the 2022-2023 season, is investigated. Moreover, cognitive anxiety measured in the 2017-2018 season is examined as a possible mediator in this relationship.

Data Analysis

Data was analyzed using IBM SPSS Statistics (Version 29.0; IBM Corp., 2022). Descriptive statistics were calculated for sex, age, and rating, MT, and cognitive anxiety of the participants. Correlations between MT, cognitive anxiety, age, and rating were calculated, and partial correlations were utilized to control for the effect of age. Assumptions for a regression and mediation analysis were examined, specifically: absence of multicollinearity, normality of residuals, linearity between the dependent and independent variables, and homoscedasticity. A subsequent regression analysis was performed, investigating the effect of MT on rating, whilst controlling for age, using the enter method. Afterwards, the PROCESS macro (Hayes, 2022) model 4 was used to test the mediation hypothesis, whilst using age as covariate, to control for its effect. Finally, the various subscales of MT were investigated exploratively. Correlations were calculated and a subsequent regression analysis based on the forward method was run.

Results

Confirmatory Results

Descriptive Statistics and Correlations

Table 1 shows descriptive statistics, correlations, and partial correlations controlling for age. Rating of the 2022-2023 season and Mental Toughness (MT) showed a significant negative moderate partial correlation (r = -.31; p < .001). In other words, higher MT is correlated with better performance (since a lower rating is better), when controlling for age. Subsequently, cognitive anxiety showed significant correlations with both rating and MT, specifically a positive small correlation with rating (r = .17; p = .006) and a negative moderate correlation with mental toughness (r = -.44; p < .001). Thus, when controlling for age, more cognitive anxiety is associated with worse performance (higher rating) and less MT.

Table 1

Descriptive Statistics & (Partial) Correlations

	M	*SD*	1.	2.	3.	4.
1. Age	13.14	2.13	-			
2. Rating 2022-2023	3.83	1.90	-.21**	-		
3. Mental Toughness	3.57	0.29	-.24**	-.24** (-.31**)	-	
4. Cognitive Anxiety	17.19	5.68	-.17*	.17* (.21**)	-.46** (-.44**)	-

Note. M and *SD* are used to represent mean and standard deviation, respectively. * Indicates $p < .05$. ** indicates $p < .01$. Numbers inside parentheses indicate partial correlations.

Regression Analysis

Assumptions. Assumptions have been tested and output can be found in Appendix C. Firstly, normal distribution of residuals was examined via predicted probability (P-P) plot. No evidence for violation has been found as no deviation in the plot was observed. Subsequently, the scatterplot of residuals showed even spacing. Therefore, no evidence has been found for violation of homoscedasticity. Furthermore, no violation of linearity between dependent and independent variables has been found, since the scatterplots show random distribution. Finally, multicollinearity was not found, since Variance Inflation Factor for every variable is below 5.0.

Analysis. The regression analysis examined the effect of MT on rating, whilst controlling for age. To discern the unique variance explained by MT, two separate regression models using the enter method were run. The first only using age to explain tennis rating and

the second both age and MT. Subtracting the variance explained of the second model from the first grants the unique variance explained by MT. Model summaries can be found in table 2. In model 1, age was a significant predictor of tennis rating (t = -3.85; p = .006) and accounted for 4.44% of the variance (Appendix D). Adding MT as independent variable in model 2 resulted in another significant predictor (t = -4.22; p < .001), as can be seen in Table 3. Model 2 accounted for 13.50% of the variance in tennis rating. Subtracting this percentage from that found in model 1 gives 9.06% explained variance in tennis rating by MT, controlling for age.

Table 2

Model Summary of the Regression Analysis

Model	*R*	R^2	Adj. R^2	Std. Error
1	.21[a]	.04	.04	1.86
2	.37[b]	.14	.13	1.78

a. Predictors: (Constant), Age

b. Predictors: (Constant), Age, Mental Toughness.

Table 3

Regression Model 2, Predicting Rating of the 2022-2023 Tennis Season

	B	*SE*	95% CI		*t*	*p*
			LL	*UL*		
Constant	14.32	2.09	10.20	18.43	6.87	< .001
Age	-0.24	0.07	-0.38	-0.12	-3.85	< .001
Mental Toughness	-2.01	0.48	-2.95	-1.07	-4.22	< .001

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit.

Mediation Analysis

The same assumptions hold for the mediation analysis as the regression analysis. However, in the mediation analysis pathways *a* and *b* (see Figure 1) must be examined separately. No evidence was found for violation of any assumptions (Appendix E). Pathways *a* and *b* can both be found in Table 4. For both, age was included as covariate. For pathway *a*, evidence has been found for MT being a significant predictor of cognitive anxiety (t = -6.32; p < .001), accounting for 21% of the variance in cognitive anxiety. In pathway *b*, cognitive anxiety was found to be a nonsignificant predictor of rating, when accounting for age and MT. Despite both pathways being found significant, this can be accounted mostly for by MT and not cognitive anxiety. This is further supported by the confidence interval of the indirect effect (via cognitive anxiety) including zero (*LL* = -0.76; *UL* = 0.18; Appendix F). Therefore, no evidence has been found for a mediating role of cognitive anxiety in the relation between MT and future tennis rating.

Table 4

Mediation Models for Pathway a and b

	R^2	*B*	*SE*	95% CI		*t*	*p*
				LL	*UL*		
Pathway *a*	0.21**						
Constant		45.62	5.95	33.87	57.37	7.66	< .001
Mental Toughness		-8.58	1.36	-11.26	-5.90	-6.32	< .001
Age		0.16	0.19	0.38	-0.21	0.87	0.38
Pathway *b*	0.14**						
Constant		12.95	2.42	8.17	17.73	5.35	< .001
Mental Toughness		-1.75	0.53	-2.79	-0.71	-3.31	.001
Cognitive Anxiety		0.03	0.03	-0.02	0.08	1.11	0.27
Age		-0.26	0.07	-0.39	-0.13	-3.91	< .001

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit. * Indicates $p < .05$. ** indicates $p < .01$.

Exploratory Results

Partial correlations between the various subscales of MT and future tennis performance, controlling for age, were calculated (Table 5). Notably, every individual subscale seems to be significantly correlated to rating of the 2022-2023 tennis season, except the challenge subscale. A regression analysis was performed using the forward method, including the significant subscales and age. Three models were found to be significant (Table 6). The final model is shown in Table 7, which includes confidence in ability and life control as significant predictors of rating. When controlling for age, these two subscales account for 9,8% of the variance in tennis rating.

Table 5

Partial Correlations of the Subscales of Mental Toughness, Controlling for Age

	Challenge	Commitment	Emotional Control	Life Control	Confidence in Ability	Interpersonal Confidence
Rating	-.100	-.204**	-.208**	-.251**	-.304**	-.173*

Note. * Indicates $p < .05$. ** indicates $p < .01$.

Table 6

Model Summary, Predicting Rating Through Mental Toughness Subscales

				Change Statistics				
Model	R	Adj. R^2	Std. Error	R^2 Change	F Change	df1	df2	Sig. F Change
1	.239a	.051	1.85	.057	10.22	1	169	.002
2	.323b	.093	1.81	.047	8.83	1	168	.003
3	.380c	.129	1.77	.041	7.93	1	167	.005

a. Predictors: (Constant), Life Control

b. Predictors: (Constant), Life Control, Age

c. Predictors: (Constant), Life Control, Age, Confidence in Ability

Table 7

Regression Model 3, Predicting Rating Through Mental Toughness Subscales

	B	Std. Error	Beta	t	Sig.
(Constant)	13.47	1.83		7.37	< .001
Life Control	-.627	.40	-.13	-1.56	.121
Age	-.262	.07	-.29	-3.84	< .001
Confidence in Ability	-1.12	.40	-.25	-2.82	.005

Discussie

The purpose of this study was to examine the effect of Mental Toughness (MT) on future tennis performance and whether this relationship was mediated by Cognitive Anxiety (CA). Based on the reviewed literature, the following hypotheses were investigated:

Hypothesis 1. Mental Toughness is a significant predictor of Future Tennis Performance.

Hypothesis 2. The relationship between Mental Toughness and Future Tennis Performance is mediated by Cognitive Anxiety.

The first hypothesis was supported. Firstly, the results suggested a significant negative correlation between MT and future tennis rating, suggesting high MT to be associated with better tennis performance in the future. Moreover, the regression analysis found MT to be a significant predictor of tennis rating. Thus, the current study indicated that MT could be considered a significant predictor of long-term tennis success. As to the second hypothesis, MT and cognitive anxiety showed a significant negative correlation. Indicating mentally tough athletes may experience less cognitive anxiety. In contrast, no evidence has been found for a significant negative correlation between CA and future tennis performance. A mediating

role for cognitive anxiety was therefore not likely. This was supported by the mediation analysis, finding no evidence for cognitive anxiety being a mediator in the relationship between MT and future tennis performance. Thus, no evidence has been found for the second hypothesis.

The finding that MT is associated with sports performance is in line with previous literature, as Hsieh and colleagues (2023) reported MT to be correlated to sport performance and Cowden (2016) reported the same in tennis, respectively. The current study found a zero-order correlation between MT and future rating of r = -.24 (p < .05). This is similar to the r = .30 as found by Hsieh and colleagues (2023) for ball sports and the r = -.29 reported by Cowden (2016) in tennis. However, the correlation reported by the current study is a little smaller. This could be accounted for by the difference in time span. The current study reports a prospective correlation and the two other studies a cross-sectional correlation. The longer the time between measurements, the smaller the correlation is expected to be. Moving on, the variance accounted for by MT to predict future tennis rating (R^2 = 9.06) could be labeled as small (Cohen, 1977). Regardless, it does provide a significant contribution and should therefore be considered of interest.

The results of this study can enhance the selection procedures of the KNLTB by assessing MT and possibly increase the chances of success in their athletes by implementing MT training. Incorporating MT assessments may help identify athletes with higher potential for future success. Additionally, the findings can inform psychological skills training programs by emphasizing MT training among their athletes. Regarding CA, no evidence has been found for its success in either predicting or influencing future performance, suggesting it should not be included in selection criteria. Since the current study did not examine CA's effect on current tennis performance, it cannot make statements regarding impact of CA training on athletes.

Strengths and Limitations

The current study had several notable strengths and limitations. As far as we are aware, it is the first of its kind to utilize a prospective design, which enabled the coupling of MT to future performance, an area previously unexplored. This design allowed for careful inference of a temporal relationship, with MT showing a significant correlation with future tennis performance, thereby supporting further research into a potential causal relationship. However, a limitation was that MT was only measured during the 2017-2018 tennis season and not in the 2022-2023 season. This limited our ability to control for effect of change of MT over time. Moreover, the study could not examine the dynamic nature of MT.

Another point of interest is the study's sample, consisting of 171 young tennis players, most of whom ranked in the top 200 of their birth year during the 2017-2018 season. Given the aim of improving the KNLTB's selection processes to better compete in elite tournaments, this sample was highly suitable. However, this specificity makes it difficult to generalize the results to the broader population, such as recreational tennis players, thus affecting its external validity. Additionally, the sample consisted of Dutch players exclusively. Gucciardi and colleagues (2016) provided evidence for some cultural invariance in MT but suggested cultural adjustment of their questionnaire (MTI; Middleton et al., 2013) to better account for contextually important aspects of the concept. The current study utilizes the MTQ-48, but as far as we know no research has been done regarding its cross-cultural validity. Thus, caution regarding the external validity across cultures for the current study is useful.

With regard to study design, a potential issue is the risk of attrition bias. Although all participants were active tennis players during the initial measurement, some stopped competing in subsequent years, especially during the COVID-19 pandemic when tournaments were canceled. Not all players became active again post-pandemic. Since mentally tough individuals are known for their persistence (), it is possible that those with lower MT were

more likely to drop out, leading to systemic rather than random dropout, which could have skewed the results.

Lastly, our use of the Dynamic Playing Strength System (DSS) had both pros and cons. One limitation is that we did not remove the players who stopped competing from the sample. Their ratings stayed relatively stable, inching towards a beginner rating of 9.000 each year. The lack of an effect could lead to underreporting of correct effect sizes and therefore affecting the results. However, when a player is active, their rating is a highly accurate representation of performance during the season. The use of continuous data in the player ratings offers a more precise operationalization of tennis performance compared to the ordinal scales used in other research (Cowden, 2016). Additionally, because the continuous scale is independent as opposed to the interdependence of the ordinal scale, analysis of the data was more reliable.

Implications for Future Research

Given the limitations of the prospective design, future research could address the current shortcomings by implementing a longitudinal study design. Especially measuring both MT and tennis performance over several time points could inform us to the dynamic nature of MT and be able to make stronger statements regarding the temporal relationship between MT and tennis performance. Also, it would be interesting to examine whether MT might have the same effect on future performance in other sports and therefore be able to generalize the predictive effect of MT to general future sport performance.

Finally, it could be interesting examine whether tennis performance conforms to a specific MT profile. Previous research has indicated inter-sport variance in MT (Thelwell et al., 2005). In extension, Bull and colleagues (2005) proposed the existence of different ‘types’ of mental toughness, depending on sport in question. In other words, the unique circumstances of each sport influence the different components of MT differentially, resulting

in a sort of profile of MT most useful for every sport. The unique circumstances of tennis may therefore suggest a specific MT profile. Investigating this unique profile may be beneficial for the informing the selection processes of tennis organizations.

Conclusion

This study aimed to explore the predictive value of mental toughness on future tennis performance and to investigate whether cognitive anxiety mediates this relationship. The study confirmed that mental toughness is predictive for future tennis performance. However, cognitive anxiety did not seem to play a mediating factor in this relationship. These results emphasize the importance of psychological attributes in competitive tennis. Moreover, life control and confidence in ability seemed to be most predictive. Future research could further explore this relationship using longitudinal study designs. Practically, these findings may enhance selection processes of the KNLTB and underscore the value of mental toughness training in athletes.

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Appendix A

The Mental Toughness Questionnaire-48

1. Ik vind meestal wel iets om me te motiveren.
2. Over het algemeen vind ik dat ik alles onder controle heb.
3. Ik vind dat ik over het algemeen een waardevol persoon ben (bijv. dat je tevreden bent met wie je bent).
4. Uitdagingen brengen gewoonlijk het beste in mij naar boven.
5. Als ik met andere mensen werk ben ik meestal invloedrijk (bijv. dat er naar jou geluisterd wordt).
6. Onverwachte veranderingen in mijn planning brengen me over het algemeen van de wijs.
7. Ik geef meestal niet op onder druk.
8. Ik heb over het algemeen veel vertrouwen in mijn eigen bekwaamheden (bijv. in de dingen die je kunt).
9. Ik doe dingen meestal plichtsmatig (bijv. omdat de dingen moeten).
10. Ik verwacht dat dingen soms verkeerd gaan.
11. Ik heb vaak een gevoel van ‘ik weet niet waarmee te beginnen’ wanneer ik verschillende dingen op hetzelfde moment moet doen.
12. Ik heb meestal het gevoel dat ik controle heb over de dingen die gebeuren in mijn leven.
13. Hoe slecht dingen ook zijn, ik heb meestal het gevoel dat ze positief aflopen.
14. Ik wens vaak dat mijn leven meer voorspelbaar was (bijv. omdat je weet wat er komen gaat).
15. Als ik dingen plan zijn er vaak onvoorziene zaken/factoren die het verpesten.
16. Ik zie het leven meestal van de zonnige kant.

17. Ik zeg meestal mijn mening als ik iets wil zeggen.
18. Af en toe voel ik me compleet waardeloos.
19. Als me een taak wordt gegeven kan men er meestal op vertrouwen dat ik het uitvoer.
20. Ik neem meestal het initiatief in een situatie wanneer ik denk dat het nodig is.
21. Ik vind het over het algemeen moeilijk om te ontspannen.
22. Ik ben gemakkelijk afgeleid van taken waar ik mee bezig ben.
23. Ik weet meestal goed om te gaan met problemen die zich voordoen.
24. Ik bekritiseer mezelf zelden zelfs als dingen verkeerd gaan.
25. Ik geef me meestal voor de volle 100%.
26. Ik laat anderen meestal weten wanneer ik overstuur ben of geïrriteerd.
27. Ik maak me meestal van tevoren druk over dingen die nog moeten gebeuren.
28. Ik voel me vaak ongemakkelijk tijdens sociale bijeenkomsten.
29. Als ik moeilijkheden tegenkom geef ik meestal op.
30. Ik ben meestal in staat vlug te reageren wanneer er onverwachte dingen gebeuren.
31. Zelfs onder aanzienlijke druk blijf ik meestal kalm.
32. Als er dingen verkeerd kunnen gaan, gaan ze meestal ook verkeerd.
33. Vaak overkomen dingen me gewoon.
34. Ik laat mijn gevoelens over het algemeen niet zien.
35. Ik vind het vaak moeilijk om een mentale inspanning te verrichten wanneer ik moe ben.
36. Als ik fouten maak, dan maak ik me daar nog dagen zorgen over.
37. Als ik moe ben, vind ik het moeilijk om door te gaan.
38. Ik vind het gemakkelijke om mensen te vertellen wat te doen.
39. Ik kan meestal een hoog niveau van mentale inspanning voor een langere tijd vasthouden.

40. Ik kijk meestal uit naar veranderingen in mijn routine.
41. Ik heb het idee dat wat ik doe geen verschil maakt.
42. Ik ben bijna nooit enthousiast voor de taken die ik moet doen.
43. Als ik vind dat iemand geen gelijk heeft, dan ben ik niet bang om met deze persoon hierover in discussie te gaan.
44. Ik houd meestal van een uitdaging.
45. Ik heb meestal mijn zenuwen onder controle.
46. In discussies geef ik meestal toe, zelfs wanneer ik een duidelijke mening heb.
47. Bij tegenslag vind ik het meestal moeilijk om vast te houden aan mijn doel.
48. Ik kan me meestal aanpassen aan uitdagingen die ik op mijn weg tegenkom.

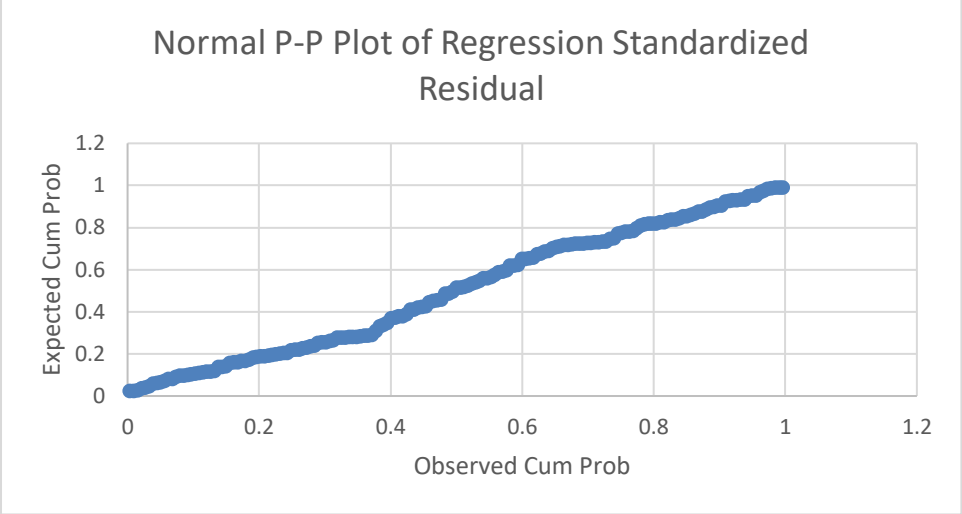
Appendix B

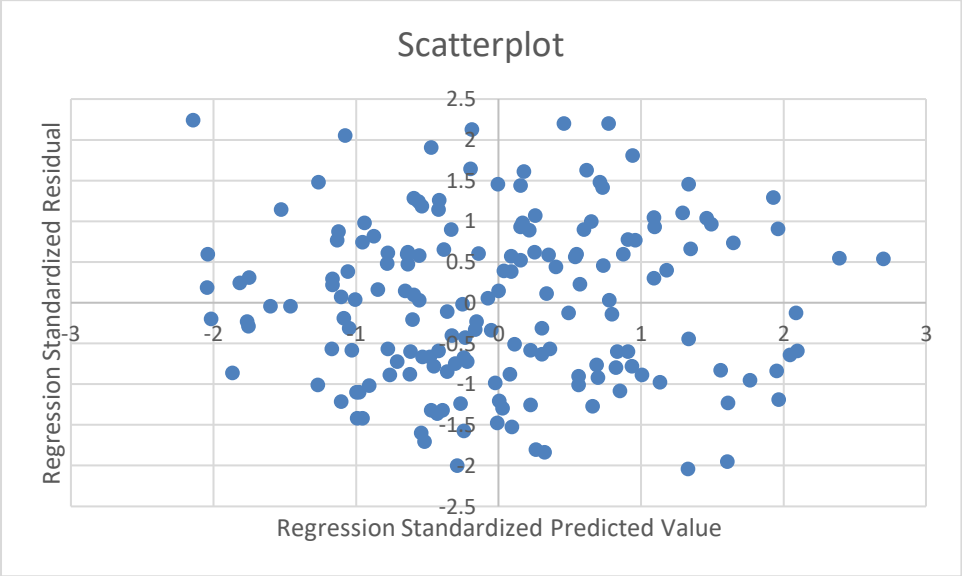
The Competitive Sport Anxiety Inventory-2R

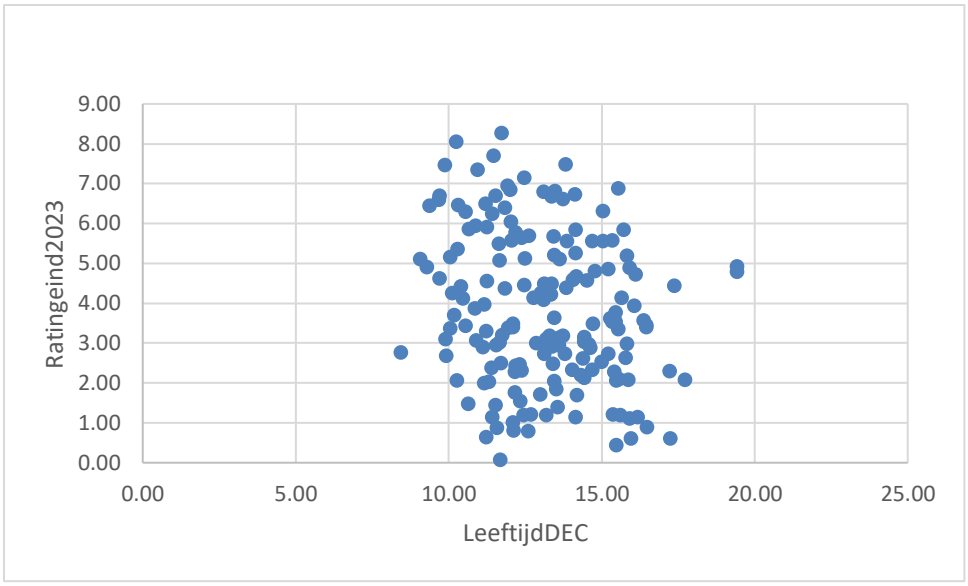
1. Ik voelde me zenuwachtig.
2. Ik was bezorgd da tik het niet zo goed zou doen zoals ik het normaal doe.
3. Ik voelde me zelfverzekerd.
4. Mijn lichaam voelde gespannen.
5. Ik was bezorgd over een eventueel verlies.
6. Ik voelde spanning in mijn buik.
7. Ik vertrouwde erop dat ik de uitdaging aankon.
8. Ik was bezorgd dat ik door de druk van mijn stuk zou worden gebracht.
9. Mijn hart was op hol aan het slaan.
10. Ik vertrouwde erop goed te presteren.
11. Ik maakte me zorgen om slecht te presteren.
12. Ik voelde mijn maag naar beneden gaan.
13. Ik was vol vertrouwen omdat ik me mentaal voorstelde dat ik mijn doel zou bereiken.
14. Ik maakte me zorgen dat anderen teleurgesteld over mijn prestatie zouden zijn.
15. Mijn handen voelden klam aan.
16. Ik was vol vertrouwen dat ik met de druk om zou kunnen gaan.
17. Mijn lijf en spieren voelde strak en gespannen.

Appendix C

Assumptions for the Regression Analysis






9.00
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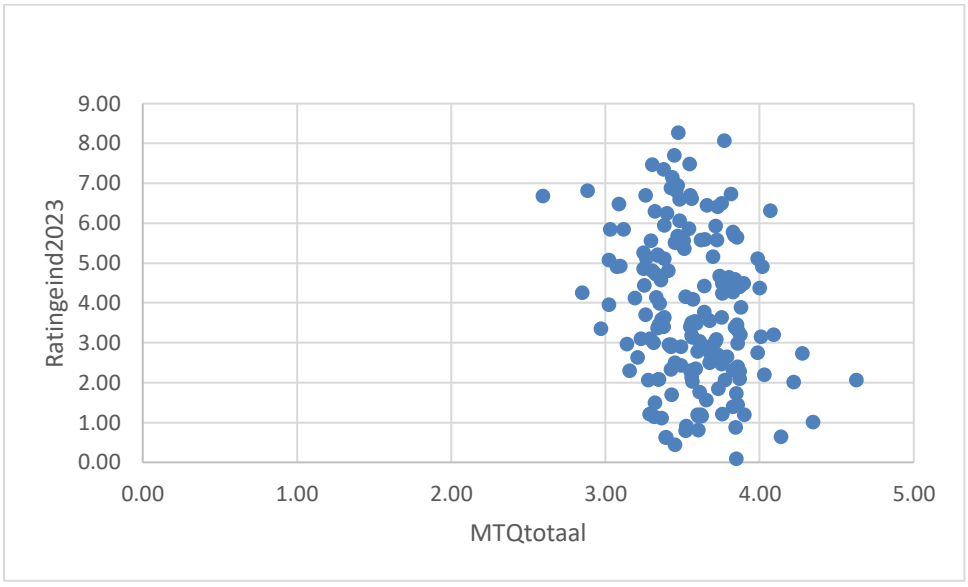
25.00
LeeftijdDEC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MTQtotaal

Appendix D

Output Regression Analysis

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	6.284	.893		7.040	<.001	4.522	8.047		
	LeeftijdDEC	-.187	.067	-.210	-2.785	.006	-.319	-.054	1.000	1.000
2	(Constant)	14.315	2.085		6.865	<.001	10.199	18.432		
	LeeftijdDEC	-.253	.066	-.284	-3.847	<.001	-.384	-.123	.943	1.061
	MTQtotaal	-2.007	.476	-.312	-4.219	<.001	-2.946	-1.068	.943	1.061

a. Dependent Variable: Ratingeind2023

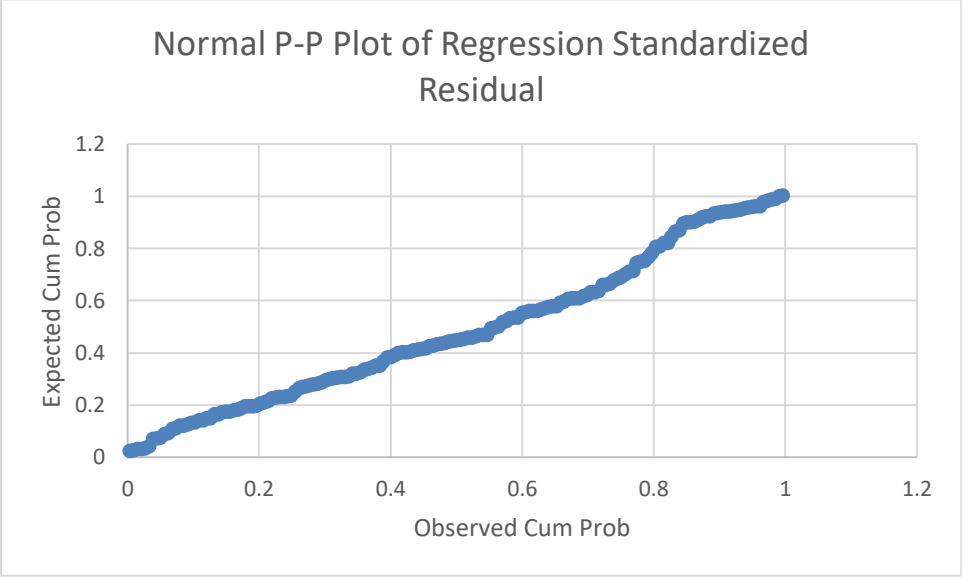
Appendix E

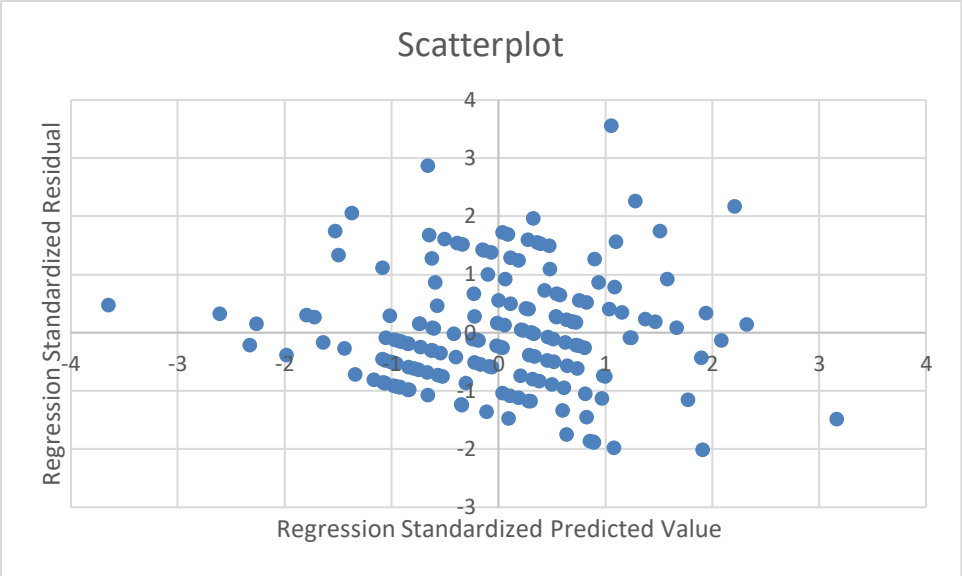
Assumptions Mediation Analysis

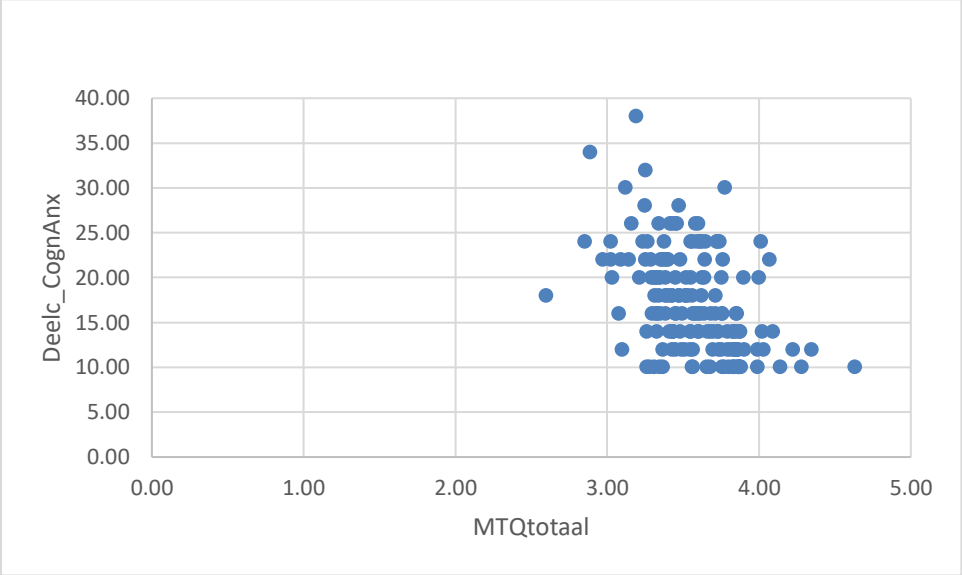
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	45.623	5.952		7.665	<.001	33.872	57.373		
	LeeftijdDEC	.164	.188	.061	.872	.384	-.207	.535	.943	1.061
	MTQtotaal	-8.579	1.358	-.445	-6.317	<.001	-11.259	-5.898	.943	1.061

a. Dependent Variable: Deelc_CognAnx



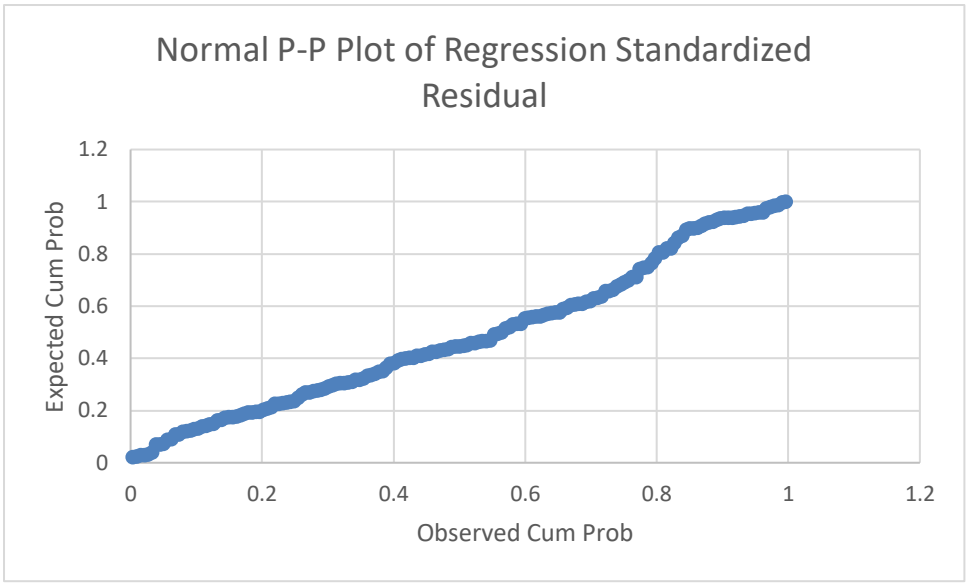


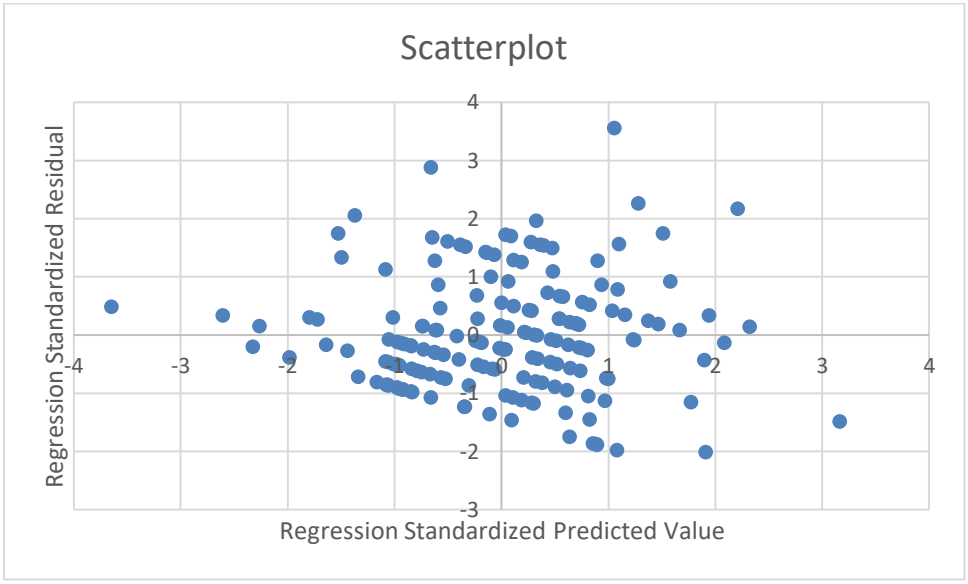


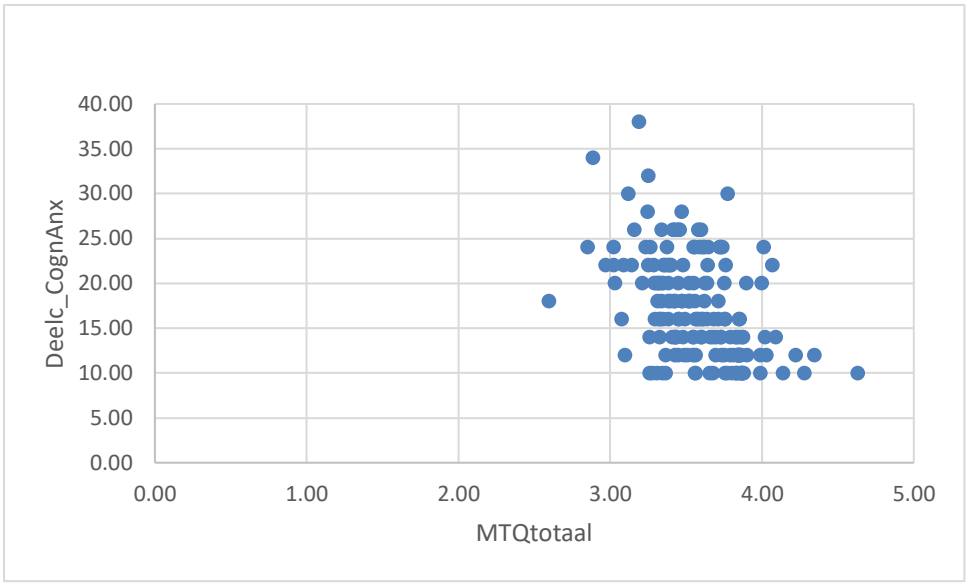
Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients			95,0% Confidence Interval for B		Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Tolerance	VIF
1	(Constant)	45.623	5.952		7.665	<.001	33.872	57.373		
	LeeftijdDEC	.164	.188	.061	.872	.384	-.207	.535	.943	1.061
	MTQtotaal	-8.579	1.358	-.445	-6.317	<.001	-11.259	-5.898	.943	1.061

a. Dependent Variable: Deelc_CognAnx



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Deelc_CognAnx
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MTQtotaal

Appendix F

Hayes Process Macro

```
Run MATRIX procedure:

***************** PROCESS Procedure for SPSS Version 4.1
*****************

          Written by Andrew F. Hayes, Ph.D.
www.afhayes.com
    Documentation available in Hayes (2022).
www.guilford.com/p/hayes3

**************************************************************
************
Model  : 4
    Y  : Ratingei
    X  : MTQtotaa
    M  : Deelc_Co

Covariates:
 Leeftijd

Sample
Size:  171

**************************************************************
************
OUTCOME VARIABLE:
 Deelc_Co

Model Summary
          R       R-sq        MSE          F        df1
df2          p
      .4634      .2148    25.6727    22.9743     2.0000
168.0000      .0000

Model
              coeff         se          t          p
LLCI       ULCI
constant    45.6226     5.9521     7.6649      .0000
33.8720    57.3732
MTQtotaa    -8.5786     1.3579    -6.3174      .0000   -
11.2594    -5.8978
Leeftijd      .1640      .1881      .8720      .3845     -
.2073      .5353

Standardized coefficients
```

```
              coeff
MTQtotaa     -.4449
Leeftijd      .0614

************************************************************
************
OUTCOME VARIABLE:
 Ratingei

Model Summary
          R       R-sq        MSE          F        df1
df2          p
      .3766      .1418     3.1463     9.1987     3.0000
167.0000      .0000

Model
              coeff         se          t          p
LLCI       ULCI
constant    12.9494     2.4208     5.3492      .0000
8.1701    17.7287
MTQtotaa    -1.7503      .5288    -3.3096      .0011    -
2.7943     -.7062
Deelc_Co      .0299      .0270     1.1084      .2693     -
.0234      .0833
Leeftijd     -.2583      .0660    -3.9149      .0001     -
.3886     -.1281

Standardized coefficients
              coeff
MTQtotaa     -.2719
Deelc_Co      .0897
Leeftijd     -.2897

************************** TOTAL EFFECT MODEL
****************************
OUTCOME VARIABLE:
 Ratingei

Model Summary
          R       R-sq        MSE          F        df1
df2          p
      .3681      .1355     3.1506    13.1658     2.0000
168.0000      .0000

Model
              coeff         se          t          p
LLCI       ULCI
constant    14.3152     2.0851     6.8654      .0000
10.1988    18.4317
MTQtotaa    -2.0071      .4757    -4.2191      .0000    -
2.9462    -1.0679
```

```
Leeftijd     -.2534      .0659    -3.8466      .0002     -
.3835     -.1234

Standardized coefficients
             coeff
MTQtotaa     -.3117
Leeftijd     -.2842

************** TOTAL, DIRECT, AND INDIRECT EFFECTS OF X ON Y
**************

Total effect of X on Y
     Effect         se          t          p       LLCI
ULCI       c_cs
    -2.0071      .4757    -4.2191      .0000    -2.9462    -
1.0679     -.3117

Direct effect of X on Y
     Effect         se          t          p       LLCI
ULCI      c'_cs
    -1.7503      .5288    -3.3096      .0011    -2.7943     -
.7062     -.2719

Indirect effect(s) of X on Y:
             Effect     BootSE   BootLLCI   BootULCI
Deelc_Co     -.2568      .2404     -.7706      .1736

Completely standardized indirect effect(s) of X on Y:
             Effect     BootSE   BootLLCI   BootULCI
Deelc_Co     -.0399      .0374     -.1188      .0273

*********************** ANALYSIS NOTES AND ERRORS
************************

Level of confidence for all confidence intervals in output:
  95.0000

Number of bootstrap samples for percentile bootstrap
confidence intervals:
  5000

WARNING: Variables names longer than eight characters can
produce incorrect output
when some variables in the data file have the same first eight
characters. Shorter
variable names are recommended. By using this output, you are
accepting all risk
and consequences of interpreting or reporting results that may
be incorrect.

------ END
```