Influence of Personality Type on Benefit Derived from Use of Muse S^{R} in Highschool Golfers

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Abstract--To improve athletic performance, various strategies have been explored, including conventional practices like physical conditioning, adequate nutrition, rest, and mental preparation. While acknowledging the efficacy of these approaches, this study seeks to widen the landscape of performance optimization by examining neurofeedback training via EEG and putting performance. Recognizing the role of sustained attention in refining technique and form, our research harnesses EEG technology to sustain peak performance. The Muse S brainWave Headset for alpha wave measurement was used on 11 youth golfers (ages 13-18) while completing 10 12 ft putts in a row. The golfers were randomly divided into a control (C) and experimental (E) group. The control ground in this study will do the identical 10 12 ft putts in a row without the Muse S headset collecting data. Previous research has shown that personality type may affect a player's response to NFT (Neurofeedback Training). Then, the participants took the Myers Briggs personality Type Indicator (MBTI)I which will assign 1 of 16 personality types to that individual. A statistical examination of personality types involving J, T, N, and T was impossible due to insufficient data. Though the p-values (0.84, 0.62, 0.58, 0.87, 0.85) indicate that the data was not statistically significant, there was sufficient information to compare personality strands P, F, S, I, and E. Although the personality strands SA and A improved considerably, the data was not statistically significant. The findings may have been even more critical if there had been more participants. NFT did not enhance putting performance, nor was personality profile/strand linked to changes in placing performance.

Introduction:

In seeking to improve athletic performance, competitive athletes come to appreciate that a holistic approach that includes multiple aspects of training is required. Of course, physical conditioning, with a combination of strength and cardiovascular and flexibility training, is crucial, as well as maintaining a balanced diet and adequate hydration. Incorporation of rest, recovery time, and proper sleep is also essential to optimize athletic performance. Lastly, thorough mental preparation, using techniques such as mental imagery, goal-setting, competition simulation, and positive self-talk can improve performance by increasing resilience and decision-making skills (Gong A et al., 2021). Mental preparation for optimal performance in training and competition should also include sharpening skills such as alertness and sustained attention. During competitions, optimal alertness enhances awareness of opponents, the playing field, and potential obstacles, and allows athletes to anticipate, respond, adjust strategies, and exploit opportunities. This, in turn, increases the athlete's level of composure and successful execution of precise movements under pressure. Sustained attention is an essential psychological construct (Gong A et al., 2021). Sustained attention is the ability to focus on an activity or stimulus over time (Fortenbaugh et al., 2017). Athletes must execute complex motor skills with precision and consistency during competitions. Sustained attention is essential for maintaining the necessary focus on technique and form ((Panchuk et al., 2016)). Sustained attention lets athletes focus on crucial cues and filter out distractions during motor preparation. This allows them to attain their full potential and the best psychological state for peak performance (Gong A et al., 2021).

Beyond their usual activities, athletes often employ specialized strategies to bolster sustained attention. Engaging in mindfulness exercises, such as focused breathing and visualization, can amplify concentration and cognitive endurance (Hillman, et al., 2008). Additionally, athletes might integrate intermittent micro-breaks into their routines, utilizing methods like the Pomodoro Technique, which alternates intense focus with brief relaxation to optimize attention maintenance. A practical method to enhance sustained attention is neurofeedback training (NFT) (Gong A et al., 2021). Neurofeedback training emerged in the 1960s as a method for monitoring and regulating brain activity. Its application extended to athletes and non-athletes in the following decades, with athletes utilizing neurofeedback to enhance focus and performance. In contrast, non-athletes sought it for stress reduction and cognitive enhancement. Its popularity grew significantly in the 21st century with technological advancements and increased awareness of its potential benefits. Neurofeedback is a non-invasive therapeutic technique in which individuals receive real-time feedback on their brainwave activity. It is used for various purposes such as improving mental health and cognitive performance and addressing certain neurological conditions (Marzbani H et al., (2016)). During guided sessions, individuals receive immediate feedback based on the desired brainwave pattern. Individuals can use this data to train better and use certain brain waves for certain activities. Electroencephalogy (EEG) is a tool for observing an individual's brain waves. An EEG picks up on brain waves at different frequencies called Alpha, Theta, Beta, Delta, and Gamma waves. Alpha waves are associated with being physically and mentally relaxed, yet still alert. Theta waves are associated with deep meditation and total relaxation. They are also associated with sleeping. Beta waves are associated with an everyday level of alertness, and finally, Gamma waves are associated with heightened perception (Desai R et al., 2015). In this state of awareness focus and attentiveness are promoted. Neurofeedback training (NFT) has been used to optimize cognitive performance in various fields, including sports, by helping athletes improve their focus and mental resilience. By fine-tuning brain activity through NFT, individuals aim to enhance their overall performance and achieve their peak potential (Lochbaum M et al., (2022)).

Golf performance and NFT are closely linked as NFT can help golfers refine their mental game. By providing real-time insights into brain activity and enabling athletes to develop better focus and emotional control, NFT has the potential to enhance a golfer's performance (Arns, M. et al., (2008)). In Arns, et. al (2008), golfers were given an assessment as well as three sessions of real-life neurofeedback instruction. In the study, six participants underwent an assessment to determine their optimal prefrontal brain states based on EEG data related to successful and unsuccessful putts. They then participated in three neurofeedback training sessions, performing a series of 80 putts with specific feedback conditions involving NoGo tones and EEG criteria. The overall percentage of successful putts was significantly more significant in the second and fourth series (feedback) of training (Arns, M. et al., (2008)). In a different study, Cheng observed that Sensory Motor Rhythm (SMR) training is a popular strategy for improving attention and focus. Sensory Motor Rhythm (SMR) training involves enhancing the brain's control over sensory and motor functions by focusing on a specific EEG frequency range. Sixteen top golfers were chosen, and they were then randomly allocated to either the SMR group or the control group. Both before and after the SMR training, participants were asked to putt while the EEG was being recorded (Cheng MY et al., (2015)). The SMR NFT groups showed improved putting performance as measured by the proximity of the ball to the hole. Both of these studies show that neurofeedback is a potential technique for enhancing putting performance in golfers. Although NFT is an excellent way to increase attention and focus it is not always practical. For example (Ring et al., (2015)) found no change in putting performance before and after NFT.

Many different methods are used for NFT. The Muse S is a wearable neurofeedback device designed to enhance the user's cognitive performance and mental focus, all to create better endurance and sustained attention. It works by using EEG technology to monitor an individual's brainwave activity in real time during training or competitions. The device connects to a software application called Optitrain via Bluetooth that provides immediate feedback through visual and auditory cues such as colors on a screen or music playing. This allows individuals to learn to regulate their alpha waves and achieve an optimal mental state. Optitrain is beneficial in both athletic and non-athletic settings. In a review done on school children, NFT was utilized to enhance focus and concentration in children with Attention-Deficit/Hyperactivity Disorder, resulting in significant improvements in their attention span and cognitive performance (Sampedro L et al., (2021))

Optitrain has been shown to improve athletic performance. Two notable studies have provided compelling evidence for the effectiveness of neurofeedback training (NFT) in enhancing focus and sustained attention among athletes. In a survey by Gong A et al., (2021), athletes from various disciplines underwent NFT sessions using EEG technology. The results demonstrated a significant improvement in their ability to sustain attention during both training and competition scenarios. This finding underscores the potential of NFT as a valuable tool for optimizing cognitive performance across different athletic domains. Similarly, Rydik et al.,(2023) reviewed NFT's impact on athletes' focus and concentration and found that NFT improved sports performance in a variety of sport-related activities, including golf. Through a series of NFT sessions, participants exhibited enhanced focus, leading to improved decision-making and overall performance (Rydzik Ł et al., (2023)). Another study looked at whether neurofeedback training could boost golf putting performance. It compared two methods of NFT: Focus Band and Opti Brain. Opti Brain showed a 16% increase in successful 12-ft putts after 15 training sessions compared to Focusband (Gook (2018, July)). However, not everyone experiences biofeedback success, which may be attributed to personality type. Langebrunner (unpublished) examined the personality type of junior golf players using the Focus Band during putting. Golfers putted ten times from PD50, which was the distance of the ball from the hole that resulted in 50% of shots made. During this, the golfers wore the Focusband which identified the EEG profile that correlates best with successful putts. The following golfers used the Focusband and putted ten more times from PD50. If the optimal EEG profile is NOT yet attained, tone stops. When the EEG profile is attained, then the golfer takes the putt. Langebrunner observed that 2 out of the four personality types using the Myers-Briggs Personality Type Indicator (MBTI) improved putting performance by 37.5% and their focus improved by 41.37%. The two personality types were INFP(Idealistic and creative, values authenticity and personal meaning) and INTJ(Analytical and strategic, values efficiency and problem-solving). These studies highlight the versatile applications of Neurofeedback and how Optitrain's neurofeedback technology can have many roles in optimizing cognitive functions across various age groups and domains (Marzbani H et al., (2016)).

The originality of our study lies in its focus on comparing adolescents to adults within the context of neurofeedback training (NFT) and their respective personality profiles. Our research aims to investigate whether there exists a correlation between NFT utilization and personality traits in these two distinct age groups, shedding light on potential developmental differences and contributing to a deeper understanding of the impact of personality characteristics on NFT across the lifespan. High-school-aged golfers will participate in a series of NFT sessions using EEG and Optitrain technology. Variability in whether athletes benefit from NFT will be examined, with a focus on personality type as a possible influence.

Methods:

This experiment involves 11 youth golfers between the ages of 13 and 18, including four females and seven males. The data was collected at Legacy Golf Course in Faribault, MN. This study was approved by the Shattuck-Saint Mary's School (SSM) Ethics Review Board. During meetings with prospective study participants, the golfers viewed the consent form, addressed any questions, and allowed participants the option to decline the study without consequence. For those willing to participate, signed and dated consent forms were collected. These golfers consistently score in the top 10-20 leaderboard during competitions. The study's participants are from the Tier 1 Golf Center of Excellence (COE) team, comprising 10 to 15 young golfers ranging from 7th to 12th grade.

The Muse S brainWave Headset from OptiBrain (model number: MS-02) was used to measure Alpha waves. The iPad, equipped with the OptiTrain software from OptiBrain, administers the MBTI survey. The preparation phase ensured the Muse S was charged and correctly connected to the iPad while verifying that OptiTrain was loaded on the device. Muse chimes and gives step-by-step instructions on what to do when it is on the participant's head. The muse will say "focus" to lower the volume of the music, which would take 5 to 10 seconds, it will say set but to the ball then it will indicate when to make the putt. An iPad charger was kept available to maintain phone charge during the experiment, and golf balls were prepared with Clorox/alcohol wipes on hand to sanitize any reusable equipment passed between each participant. Before the data collection phase, Participants in the experimental group first had a brief introduction to using the MUSE device, while taking 2-3 putts The MUSE device provides auditory cues, such as chiming and step-by-step instructions, including prompts like "focus" to adjust the volume of the music, set up the putt, and when to take the putt.

The procedure for the study was organized into several steps, beginning with preparations before the first session (Table 1). Initially, the participants were randomly assigned to either the control (C) or experimental (E) group using a random name generator. In Session 1, participants were welcomed to the putting range. After completing the MBTI survey, the participant's 5-letter personality code was recorded. Participants were then asked to retrieve their putters. While they did this, the experimenters set up golf balls for the experiment. Each participant started with a practice session consisting of three 12-foot putts. The baseline collection phase started and all participants attempted ten 12-foot putts. Baseline data was collected on a separate day for all of the participants. On a different day, the data collection phase for both the control and experimental groups took place. The participants in the control group attempted these putts without the use of the Muse S and the same data was recorded as in the baseline. In the experimental group, subjects wore the Muse S device, and the same data was recorded. For both groups, the outcome of each putt was recorded and compared to baseline putting performance. The distance from the hole was measured if the ball did not go into the hole (cm).

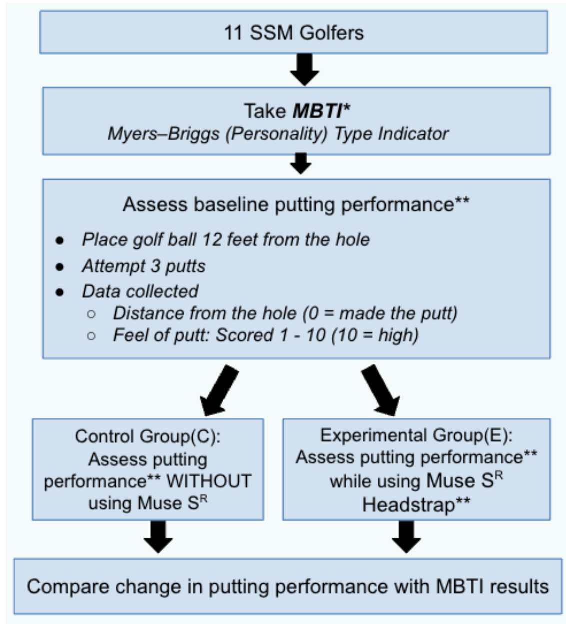

Table 1: (Experimental Protocol)

Before the data collection phase, participants in the experimental group first had a brief introduction to using the MUSE device, which involved two to three putts. The MUSE device provides auditory cues, such as chiming and step-by-step instructions. This includes prompts like “focus” to adjust the volume of the music, set up the putt, and when to take the putt. The MBTI was a self-report questionnaire that assigned the individual to 1 of 16 personality types based on preferences and perceptions of the world. Possible personality strands might include A (Assertive), SA (Socially Assertive), T (Turbulent), E (Extraversion), I (Introversion), S (Sensing), N (Intuition), F (Feeling), T (Thinking), P (Perceiving), And finally J(Judging). The statistical analysis that was used for this study was the T-Test Calculator for two independent Means.

Results:

This experiment examined putting performance in youth golfers between the ages of 13 and 18 with or without the use of the MUSE S NFT device. There were no significant differences in the average change in putting distance from baseline in both control and experimental groups with or without the use of the Muse S NFT (Table 2). Both the neurofeedback group and the control group improved their putting similarly from start to finish. Golfers categorized under the A and SA personality types demonstrated a higher likelihood of benefiting from the MUSE S system. However, compared to those who did not use the Muse S, the difference did not reach statistical significance (P=0.15 for both). As shown in Table 3, there was insufficient data for statistical analysis for personality types with J, T, N, and T. However, there was enough data to compare personality strands P, F, S, I, and E but the data was not statistically significant according to the p-values (p= 0.84),(p= 0.62), (p= 0.58), (p= 0.87), (p= 0.85). Golfers with personality strands SA and A demonstrated slight improvement, but that data was still insignificant. However, since there was a big difference between the SA, and A strands and the rest of the personality strands it is still something to look into and that data might have been significant if there was a larger participant count.

All Golfers		
	Controls (6)	Experimental (5)
Ave Change in Putting Distance	30.9	19.6
t	0.58	
p	0.58	

Table 2: Average change in putting distance from baseline in control and experimental group

Personality Type	Diff Ave Exp Vs. Ave Control	t-value	p-value
A	-29.86	1.6	0.15
T	Not enough data		
SA	-23.46	1.6	0.15
E	-6.8	0.2	0.85
I	1.6	-0.17	0.87
S	-4.8	0.6	0.58
N	Not enough data		
F	-11.9	0.52	0.62
T	Not enough data		
P	-6.737	0.2	0.84
J	Not enough data		

Table 3: Difference of putting distance Averages of Personality Type Between Control and Experimental

Limitations:

This study has some limitations that should be noted. The main significant limitation is the low number of study participants. A more substantial number of participants would make the data more reliable. Having a bigger sample size would make the data have a more significant impact on the topic. Second, there is a lack of a professional EEG. This study cannot acquire a medically used EEG machine, which would provide more data, and that data would be more reliable. Thirdly, It's hard to take care of uncontrollable variables and distractions that could have affected the integrity of this data. The different players' skills could be connected to whether or not the putt was made or not. Quality of the players' clubs: Each player had their own club, each a different brand and quality, from new to old. This could affect the outcome result. When collecting the subject's personality types the MBTI was chosen for this study but another personality assessment could have been used that might have impacted the data. The baseline putting task was recorded 14 days after the experiment began.

Implications:

When considering the integration of NFTs into athletic training, it was clear that utilizing NFTs for every athlete would not be the most effective approach. Only those athletes who were either interested in the concept or possessed a specific personality trait that has a quicker adaptation to NFT. This approach involves personalizing the data to resonate with each athlete's particular characteristics and preferences. By individualizing the training and introduction to NFTs, athletes might improve their putting ability. Interested athletes may find it easier to understand the value and potential of NFTs in enhancing their putting ability and their ability to stay focused longer.

Discussion:

All athletes know the importance of physical conditioning, nutrition, and hydration, as well as the critical role of rest and recovery in improving athletic performance. Techniques such as mental imagery, goal-setting, positive self-talk, and skills like alertness and sustained attention, are underscored for their significant impact on performance. Sustained attention, the ability to maintain focus on specific tasks or stimuli over time, is pinpointed as a crucial element for executing complex motor skills accurately and consistently. Previous research suggests that an athlete's ability to remain mentally engaged and attentive enables more effective strategy adjustments and the execution of movements under pressure, ultimately fostering peak performance.

In this study wearing the MUSE S NFT headband did not appear to enhance putting performance. These results are similar to Ring et al., (2015) who found that while the neurofeedback group learned to adjust their brain activity to resemble that of experts, this didn't lead to better-putting performance in recreational golfers ages 21 to 23. In this study, 24 male golfers were split into two groups: one received neurofeedback training, and the other, a control group, received no brain-based feedback. Both groups practiced putting under varying pressure conditions before and after the training. The neurofeedback group's training involved listening to tones that changed based on their brain activity. The control group heard pre-recorded tones unrelated to their brain activity. Since the golfers in both Ring et al.,(2015) and the present study were recreational this could affect the benefit received from NFT.

Similarly, Grant (2022) examined if NFT would influence putting performance. Grants' subjects included male and female volunteer golfers, aged 18 to 82 with a USGA handicap between -5 and 40. Brain measures and neurofeedback training were administered using an EMOTIV® headset measuring brain activity from 14 locations. Participants then engaged in a putting task in a lab, using an EMOTIV® headset to measure EEGs. Initially, they took five practice putts followed by ten recorded 12-foot putts to establish a baseline. Participants were then randomly assigned to receive either correct feedback (which reflected increasing brain synchronization with volume changes) or incorrect feedback (reflecting decreasing synchronization or random volume changes) via the volume of instrumental music. After a session of feedback-guided practice, they attempted ten more putts, with outcomes and EEG responses recorded. Grant (2022) also observed no effect of neurofeedback on putting performance in golfers with a variety of skills.

In contrast, Gook (2018) evaluated the impact of two neurofeedback training devices on golf putting performance, while also observing changes in relevant brain patterns. Eleven golfers (7 males, 4 females) with an average age of 59 years and varied golfing experience participated. They began by putting 10- and 12-foot straight putts on an outdoor green to establish baseline performance metrics such as quality of feel, zone scoring, and total putts made. Participants were then randomly assigned to use either the Focus Band or the Opti Train device first, to control for any potential order effects. They practiced with the assigned device for 3-5 minutes without making putts, followed by five practice putts with the device, and then 15 training trials. After training, they performed ten post-test trials. Gook concluded that the FocusBand increased putting performance by 7% although that data was not significant. Optitrain increased putting performance by 55% demonstrating a better benefit to NFT.

Similarly, Arns et al., (2008) observed that putting performance increased in six golfers (3 female, 3 male) after 3 sessions with NFT feedback compared to those without. Participants were all amateur golf players with an average handicap of 12.3. The core of the experiment involved a series of training sessions where participants performed a total of 320 putting attempts, structured in an ABAB design. This meant that the training was divided into four sets: the first and third sets did not involve any feedback (A phases), serving as a control to compare against the second and fourth sets (B phases), where participants received real-time neurofeedback. During these feedback sessions, a continuous "NoGo" tone was played, which would only stop once the participant's EEG signals matched the previously established criteria for an optimal putting brain state. Participants were instructed only to execute their putt after the tone had ceased, suggesting that they were in the right mental state for a successful attempt. This method aimed to train participants to self-induce the optimal brain state for putting, thereby improving their performance. On average, NFT enhanced participants' performance by 25%. The difference in results between the current study and those of Ring et al.,(2015), and Grant (2022) compared to data from Arns et al., (2008), and Gook(2018) could be due to various reasons. The methodological differences between studies could affect the data. For example, these studies all used an NFT device for varying periods. In addition, the skill level/handicap could have come into play with whether a golfer benefited from NFT. A golfer with better skills might be better at receiving benefits than recreational golfers. Lastly, the type of NFT device used might contribute to conflicting data in other studies. Many different NFT devices were used, and each study used a different brand and software.

According to the results of this study, personality type does not influence putting ability and the ability to receive substantial benefits from an NFT device. This is in contrast to Langenbrunner (unpublished), which demonstrated an increase in placing performance with NFT, as shown by the PD50. Using the MBTI, Langebrunner found that two of the four personality types demonstrated a rise in putting performance: INTJ(49.38% increase) and INFP(41.37% increase). This could suggest a complex relationship between personality traits and the effectiveness of NFT devices in enhancing specific motor skills. The current study suggests that the benefits of NFT have no connection to an individual's personality type. However, due to the small sample size, there was not enough data for a statistical analysis of all personality types. In addition, the use of a different personality questionnaire could affect the data. This suggests a complex relationship between our bodies and minds and how we train to reach our best performance. Further research is required to find a correlation between personality type and benefits received from NFT.

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