Introduction

For both recreational and high-performing golfers, mental and physical skills are required to achieve optimal performance (Brouziyne & Molinaro, 2005). Although physical interventions and training aids are prolific in the golf industry, few mental skills training devices are at golfers' disposal. Without access to effective technology that can improve mental skills, golfers lack tools to help them overcome psychological deficits that negatively impact their golf performance. This pilot study investigates if Meta-Brain Labs technology can fill the gap golfers experience in their mental performance training.

Meta-Brain Labs has developed a technology and a training regime that could satisfy golfers' mental-training needs. Meta-Brain Labs technology trains golfers using a two-step process. In the first step, golfers' beta and theta brain waves are measured using an electroencephalography (EEG) headband as they answer probing questions about their golf game. This protocol is validated by other beta and theta neurofeedback training devices that have previously been used successfully as a therapy in clinical settings (Egner et al, 2002; Graap & Friedes 1998).

Step two of the training process is informed by step one. Beta and theta wave data collected from the EEG headset is analyzed using computational and statistical techniques to identify patterns and relationships between brain activity and stated beliefs (mindsets). Based on these results, the Meta-Brain Chatbot recommends affirmations. The golfers choose and verbalize affirmations that are then recorded with the Meta-Brain Labs app. These self-recorded affirmations are played back through the Meta-Brain Labs app twice a day. The recommended training period is two weeks. Meta-Brain Labs's technology is informed by the work of company founder Alexandrea Day (Day, 2022).

In this pilot study, we test the effectiveness of Meta-Brain Labs technology in helping golfers reduce performance anxiety when putting. We attempted to answer the following questions:

1. Does Meta-Brain Labs technology change golfers' putting performance?
2. Does Meta-Brain Labs Technology change golfers' putting mechanics?

3. Does Meta-Brain Labs technology change golfers' performance anxiety about putting?

This pilot study focuses on a narrow part of golf performance – putting. Putting is frequently the focus of golf studies because it provides a discrete skill that can be performed more easily under controllable conditions. This is preferable to studying golfers' overall play because of the variability of conditions golfers experience playing a round of golf. For example, golf courses are designed at different lengths and weather conditions are unpredictable. By contrast, putting tasks have less variables. The length of putts used for putting tasks can be pre-determined and the conditions of the greens can be prescribed. It is for these reasons that many golf studies, including this one, focus on putting tasks (Mullen et al., 2005; Shin & Park, 2019).

Theoretical Constructs Underpinning Meta-Brain Labs Technology

The design of Meta-Brain Labs technology is underpinned by adaptive theory – a subdiscipline of cognitive-behavioral theory (Beck, 2000). Adaptive theory focuses on the role of unconscious beliefs that affect behavior (Bargh, 2006; Freud, 1961; Masters, 2012). The theory suggests that individuals engage in cycles of thoughts and feelings in which their beliefs about themselves and their environment influence their behavior. Cognitive-behavioral interventions aim to help individuals identify and change maladaptive beliefs to improve their behavior.

The application of CBT through therapy identifies negative or distorted beliefs and challenges them through various techniques such as cognitive restructuring, behavioral experiments, and problem-solving. In adaptive theory specifically, the goal is to identify and reverse negative or distorted beliefs through cognitive restructuring (APA, 2023). For example, golfers may publicly state confidence in their putting skills, but these conscious statements may conflict with their unconscious beliefs. Successful therapeutic interventions identify self-defeating unconscious beliefs, refute them, and then modify them.

The Meta-Brain Labs technology is designed to make adaptive therapy more easily accessible to golfers. It helps golfers identify unconscious beliefs, their mindsets, that become barriers to optimal performance and reverse them. Maladaptive thinking patterns are identified by reading beta and theta waves with an EEG headset. It then helps golfers retrain their beliefs through self-selected affirmations presented by the Meta-Brain Chatbot, and recorded to the Meta-Brain Chatbot app. This process trains golfers' thoughts and subsequent behaviors to be more adaptive. It is hypothesized that Meta-Brain Labs technology will benefit golfers' mental and physical performance by delivering adaptive therapy through its app.

Study Methods

Participants. Thirty golfers participated in the pilot study (Men = 29, Women = 1). All golfers were based in the USA. Participants were recruited through Meta-Brain Labs's leadership team's personal contacts and a LinkedIn post that targeted golf instructors.

The age of golfers in the study ranged from 18 to 62 years old (M = 42.64, SD = 13.42). They had been playing golf for between three and forty-five years (M = 25.75, SD = 13.56), and the age they started playing golf ranged from five to fifty-three years old (M = 16.22, SD = 9.99).

Pilot study procedures. Study materials were administered at different locations across the United States with a lead person for each group. The lead person was either a golf instructor or a member of Meta-Brain Labs's leadership team. Each administrator was provided with study protocols and instructions to test golfers on the different measurements.

During the pre-testing phase of the study, golfers completed the first survey that measured psychological beliefs about putting. The survey also collected demographic information. Golfers then completed two putting tasks, described below. During the intervention phase, golfers were trained by the Meta-Brain Labs team to use the EGG headset – beta and theta brain waves were measured during this phase. Golfers were then instructed how to use the Meta-Brain Labs app and completed two weeks

of mental training. After two weeks, golfers completed a second survey that measured the same psychological beliefs as in the pre-testing. They then repeated the putting tasks.

Measures. Validated measures of psychological beliefs were used in the study surveys, and standard putting tasks were used to measure putting skills.

Performance anxiety was measured with Martens et al. (1983) Competitive State Anxiety Inventory -2 scale (CSAI-2R). The scale consisted of three subscales that measured cognitive anxiety – the mental manifestation of anxiety (7 items, $\alpha = .83$), somatic anxiety – the physical manifestation of anxiety (5 items, $\alpha = .86$), and confidence (5 items, $\alpha = .86$). A mean score was calculated from the items of each subscale. This mean score was used for data analysis. All subscales demonstrated good reliability.

Participants were asked to think about their on-course putting performance and indicate their level of agreement on a 5-point Likert-type scale (1 = strongly disagree 5 = strongly agree). The subscales included the following example items. Somatic anxiety, 'My body feels tense.' Cognitive anxiety, 'I'm concerned about performing poorly.' Confidence, 'I'm confident about performing well.'

Implicit beliefs about golf ability were measured with Dweck's Implicit Theory Scale (1999). Dweck's Implicit Theory Scale, also known as the Mindset Scale, is a tool developed to assess beliefs about the perceived nature of intelligence and ability. The scale is based on Dweck's theory of fixed and growth mindsets, which suggests that people perceive intelligence or ability as something innate (they hold a fixed mindset), or something that can be developed (holding a growth mindset). Where beliefs sit along a fixed-growth mindset continuum predict a range of behaviors ranging from motivation, persistence, and learning. Individuals with more of a growth mindset tend to be more resilient, adaptable, and persistent in the face of challenges, while those with stronger fixed mindset beliefs may be more likely to give up or avoid challenges altogether. Mindset is a known predictor of learning and success across a range of domains (Dweck, 2006; Dweck, 2016)

In this pilot study, only the three fixed items of Dweck's scale were used. Golfers were asked to think about putting ability and respond to three statements and indicate their level of agreement on a 5-point Likert-type scale (1 = strongly disagree 5 = strongly agree). For example, 'You can change your putting technique, but you can't really change your basic putting ability.' A mean score was calculated for the three items and used for data analysis. The three-item scale demonstrated good reliability (3 items, $\alpha = .69$).

Golf tasks. Participants completed two putting tasks on a flat putting green. Because putting on a putting green is less stressful than performing on the course, study administrators induced stress with the following script that was read to golfers before each putting task.

> 'Today you will be completing a putting task to measure how well you perform under pressure. We will be videoing your putting performance for future analysis and measuring key components of your putting strokes. These metrics will tell us about your putting ability under pressure.'

The first putting task measured performance when the ball was 8ft from the hole. Golfers were asked to putt ten balls from 8ft. The goal was to hole as many 8ft putts as possible. Once golfers had performed this task, their score was recorded. The second putting task involved golfers putting five balls towards the hole from 20ft. The aggregated distance that the five balls finished from the hole was measured and recorded by the administrator.

Technical putting mechanics. Optimal putting performance requires golfers to have control over their putter face during impact with the ball. We used Blast Golf technology (2023) to measure this metric as a reflection of golfers' putting stroke mechanics. The Blast Golf system consists of two main components: a small sensor that attaches to the grip of a golf club, and a mobile app that displays and analyzes data captured by the sensor. The sensor captures stroke information including putter face angle at impact.

Data analysis procedures. All data analysis was conducted using SPSS software (IBM, 2020). Pre- and post-intervention data was analyzed using a repeat-measure ANOVA.

Ethical considerations. For this pilot study, no Institutional Review Board (IRB) review was sought. However, data was collected anonymously and identifying information was stripped from the data before analysis. Results of the study are reported in aggregate form, not individually.

Results

Data analysis indicated that between pre- and post-intervention measures, golfers improved their mental skills and putting skills. See Table 1 for descriptive statistics of the measures.

Table 1.

		Pre-Intervention		Post Intervention	
Measure	n	Mean	SD	Mean	SD
Putting (I)	30	4.47	1.90	5.30*	2.10
Putting (II)	30	109.9	67.09	73.98*	52.17
Som. Anxiety	27	2.73	.64	2.38*	.83
Cog. Anxiety	27	3.16	.82	2.81*	.89
Confidence	27	3.24	.64	3.67*	.64
Fixed mindset	28	1.96	.60	1.53*	.45
Impact angle	10	.65° open	-	.20° closed	-

** Mean difference $p < .05$*

Golfers in the study reported significantly improved putting performances after two weeks of Meta-Brain Labs training. The number of putts holed from 8ft increased from a success rate of 4.47 out of 10 to 5.30. From 20ft, the aggregated distance of 5 putts decreased from 109.9 inches to 73.98 inches. Golfers self-reported a significant reduction in anxiety following two weeks of training with the Meta-Brain Labs protocol, and their self-reported putting confidence increased. Compared to the pre-

intervention measure, golfers reported a significantly less fixed mindset post-intervention. This means that golfers were more likely to perceive putting ability adaptively -- as something that can be improved rather than something that they are innately good or bad at.

Finally, the angle of golfers' putter face in relation to their target became more stable after training with the Meta-Brain Labs material. However, this result was gained with only ten participants. Therefore, the findings lack robustness.

Discussion

Based on our sample of golfers, the findings of this preliminary pilot study suggest that Meta-Brain Labs technology can potentially help golfers improve their mental skills and subsequent putting skills. After two weeks of training with the Meta-Brain Labs technology, study participants reported less performance anxiety, less of a fixed mindset, and improved putting performance. The improved putting performance demonstrated in this pilot study could translate to an improved golf score for many players. These findings should be of interest to golfers, golf instructors, and performance coaches.

Limitations and future research. This study was limited by its small sample size and lacked adherence to study controls and protocols. For example, the study administers participated in the study and were therefore immune to how the study design attempted to induce stress while putting. Adherence to the study's recommended two-week training period was not strictly followed. Future studies, with a bigger sample size and more controls, should attempt to replicate these preliminary findings.

Conclusion

This pilot study is a good first step in testing the effectiveness of Meta-Brain Labs technology for golfers' mental skills training. Should these results be replicated, the Meta-Brain Labs technology is a promising tool for delivering adaptive therapy to golfers who can benefit from its application. Although this pilot study focused on golf putting, it is reasonable to assume that Meta-Brain Labs technology can

be equally as beneficial to other golf skills, and athletes playing other sports who are seeking mental-skill training.

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