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The Effects of Instructional Self-Talk on Quiet-Eye Duration and Golf Putting Performance

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Abstract

While the impact of strategic self-talk on performance is well documented, examination of the attentional-perceptual mechanisms of self-talk is still at early stages. This study's aim was to examine the effects of instructional self-talk on quiet-eye durations and putting performance. Thirty participants were recruited and randomly assigned to self-talk or control conditions. Participants performed a golf putting task in a mixed between (self-talk vs. control), within (pre- vs. post-intervention) design. Two 2x2 mixed-design ANOVAs were conducted for performance and quiet-eye durations as dependent variables. A mediation analysis was conducted to examine the mediating effect of quiet-eye durations on performance. Results showed that self-talk use led to longer quiet-eye durations and better performance compared to controls. The mediation analysis indicated that performance was mediated by quiet-eye durations. Discussion centers on the role of quiet-eye in motor performance, and how self-talk can assist regulating quiet-eye.

Self-talk refers to the phenomenon in which performers express verbal cues to themselves in order to regulate their performance or performance-related factors (Hardy, 2005). Self-talk can occur organically, and represents the internal dialogue of the performer (Latinjak et al., 2014). In addition, self-talk can be utilized strategically, in which case the performer uses deliberate verbal cues to promote behaviors, cognitions and emotions aimed at facilitating learning and enhancing performance (Fritsch et al., 2021). Athletes, coaches and performance consultants frequently use strategic self-talk interventions (Van Raalte et al., 1995), and such interventions have been deemed effective in enhancing performance in various sports (e.g., Perkos et al., 2002), exercise modes (e.g., Hatzigeorgiadis et al., 2018), and performance domains (e.g., Hoffman & Hanrahan, 2012).

Strategic self-talk is often defined by its instructional or motivational functions. Motivational self-talk includes cues aimed at creating pleasant affect, while instructional self-talk includes cues aimed at regulating attention (Hardy et al., 2018). Theodorakis et al. (2000) recommended the *Matching Hypothesis,* suggesting that the self-talk function should be matched to the corresponding motor task being performed. Therefore, according to the *Matching Hypothesis* motivational self-talk cues should be paired with tasks that involve endurance and gross motor movement (e.g., running, weightlifting), and instructional self-talk cues should be paired with tasks that require precision and fine motor movement (e.g., dart throwing, golf putting). The *Matching Hypothesis* was partially supported in a meta-analysis, showing that instructional self-talk was more effective than motivational self-talk when performing precision tasks. In addition, instructional self-talk was more effective when performing novel tasks compared to well-learned tasks, suggesting that the use of instructional self-talk cues might be more beneficial at the skill acquisition stage (Hatzigeorgiadis, 2011).

While the effect of strategic self-talk interventions is well-established in the experimental literature, the possible underlying mechanisms of self-talk have attracted less interest. Given the two distinct strategical self-talk functions (motivational vs. instructional) and their varying effects on different motor performance tasks, several underlying mechanisms have been suggested to account for the positive effect of self-talk on performance. Theodorakis et al. (2008) suggested that motivational self-talk is mainly, but not exclusively, underpinned by affective-cognitive processes such as increases in confidence, emotion and cognitive regulation, and effort regulation. In turn, instructional self-talk is mainly underlined by attention regulation and automatic skill execution processes.

Perhaps the most studied underlying mechanism is self-efficacy, or the confidence of performing specific performance-related tasks (Bandura, 1989). Hatzigeorgiadis et al. (2008) demonstrated that a three-week motivational self-talk intervention led to increased self-efficacy levels in young tennis players. In addition, Zetou et al. (2012) found an increase in self-efficacy as a result of an instructional self-talk intervention aimed at improving volleyball serve performance. It seems that the motor task constraints undermine the relationship between self-efficacy and self-talk function (Chang et al., 2014). Motivational self-talk has been also associated with anxiety regulation in competitive situations (Hatzigeorgiadis et al., 2009), and the ability to regulate effort during endurance tasks such as cycling (Blanchfield et al., 2014) and swimming (de Matos et al., 2021).

In contrast, attention regulation related to self-talk has not been sufficiently studied and its effect of performance was investigated only indirectly. Specifically, the use of strategic self-talk helped avoid auditory distractions while performing a computer task and a basketball free throw trial (Galanis et al., 2018). In addition, athletes reported fewer interfering thoughts after participating in a strategic self-talk intervention (Hatzigeorgiadis et al., 2004). In a series of assessments using the Vienna Test System, participants that underwent a strategic self-talk intervention showed improved alertness, vigilance, focus, selective and divided attention (Galanis et al., 2022). While the aforementioned studies have provided useful preliminary insights regarding the attention regulating self-talk mechanisms through indirect or off-the-field evidence, research examining perceptual-attentional processes directly within a sport context is lacking. Towards this direction, a sport-specific attentional-cognitive framework was adopted in the present study. Tenenbaum's (2003) *Sport-Related Decision-Making Schema* suggests that performers' real-time decision making and response execution are dependent on perceptual-attentional processes and information processing. Specifically, performers attend to relevant cues in the environment, the information is then processed and allows the performers to decide on the best course of action to perform. The performers then execute the relevant movements and alternate them if needed when new information is processed. Lastly, the performers receive feedback from the environment after the execution of the skill, which they encode for future retrieval in similar situations. Therefore, gaze behavior plays a crucial role in sport-related decision-making and response execution, and one of the most prominent perceptual-attentional elements that relates to sport performance is the quiet-eye period.

The quiet-eye period is defined as the final gaze fixation on a task-related object or location for a minimum of 100 milliseconds and within 3 degrees of visual angle prior to the initiation of the movement (Vickers, 2021). It is theorized that the quiet-eye period represents the time needed to organize the neural structures that control the visual and motor systems (Dalton, 2021). Therefore, during the quiet-eye period, the most relevant and up-to-date information is being gathered to assist the performer to execute the designated decision. Research has shown that longer quiet-eye durations are associated with better performance (Land, 2009). The relation between quiet-eye durations and increased performance has been demonstrated in several self-paced sports and tasks including dart throwing (Vickers et al., 2000), billiards (Williams et al., 2002), penalty kicks (Piras & Vickers, 2011), and golf putting (Vine et al., 2014). A meta-analysis of 27 studies reinforces the quiet-eye and performance correlation and associates longer quiet-eye durations with higher level of expertise (Lebeau et al., 2016). In addition, in a brain imaging study, a strong correlation was recorded between quiet-eye durations and readiness-potential activation, which is an indication of information processing before the execution of a movement. Therefore, visually attending to relevant cues, leads to better information processing, which in turn leads to superior decision-making and execution (Mann et al., 2011).

While the effect of strategic self-talk interventions on quiet-eye durations in a sport-related setting has yet to be investigated, the aforementioned attentional processes of attention regulation (Galanis et al., 2022) and mental effort (Galanis et al., 2016) mediated by self-talk, might imply a potential longer quiet-eye effect. Moore et al. (2012) demonstrated that quiet-eye training improved putting performance. Participants who were given explicit instructions to focus on the ball performed better, showed longer quiet-eye durations, and experienced lower heart-rate and muscle activation than their counterparts who received technical putting training. These findings support the notion that the golf ball is a relevant environmental cue in golf putting (Vickers 2012). In addition, Galanis et al. (2022) showed that a strategic self-talk intervention enhanced golf-putting performance in novice golfers. Participants using instructional self-talk cues prior to each putt, focused attention on task-relevant elements, and maintained attention focus under ego-depletion conditions. Given that strategic use of instructional self-talk can act as an attention-regulation technique, and the perceptual-cognitive nature of the quiet-eye duration, we maintain that instructional self-talk cues can be used to regulate attention to a relevant environmental cue (i.e., the golf ball), and therefore lead to longer quiet-eye durations and better performance.

The Current Study

The aim of this study was to directly investigate the effect of a strategic instructional self-talk intervention on quiet-eye duration, and subsequently golf putting performance. Instructional self-talk was used in consideration of the *Matching Hypothesis* and supporting evidence that the instructional function is more effective in promoting fine motor movement and novel tasks (Hatzigeorgiadis et al.,2011). In addition, we maintain that attention-regulation processes are the underlying mechanisms of instructional self-talk (Theodorakis et al., 2008). Therefore, novice golf players were recruited to participate in the study to better account for the mediating effect of task novelty on the instructional self-talk and performance link (Hatzigeorgiadis et al., 2011).

Quiet-eye duration was utilized as a perceptual-attentional variable in the study because of the compelling evidence relating it to the initial phases of the *Sport-related decision-making schema* (i.e., attending to relevant cues and information processing; Tenenbaum, 2003). In addition, the instructional self-talk function can be particularly effective in directing attention to relevant environmental cues (i.e., the golf ball), and therefore enhancing the durations of the quiet-eye fixation and subsequent performance (Moore et al., 2012).

The current study was a randomized – controlled trial with a mixed between (self-talk vs. control) within (pre- vs. post-intervention) design. Considering the extant literature regarding the effectiveness of strategic self-talk and its postulated attention regulating mechanism, it was expected that the participants in the self-talk condition will display better performance and longer quiet-eye durations than participants in the control condition post-intervention. In addition, quiet-eye durations were expected to mediate performance.

Method

Participants

An a priori power analysis for a mixed-design ANOVA was conducted using GPower version 3.1 (Faul et al., 2009) with a moderate effect size reported by Hatzigeorgiadis et al's. (2011) meta-analysis. Accordingly, $\bar{d}$ = .55, α = .05, *power* $(1 - \beta)$ = .80, .5 correlation among repeated measures, no sphericity correction of 1, two between conditions factor (self-talk vs. control), and two within conditions factor (pre vs. post) were used for the power analysis. The recommended sample size was 30 participants. Therefore, a convenience sample of 30 participants was recruited. The inclusion criteria were little to no prior golf putting experience and the ability to hold and swing a golf club. The inclusion criterion of little to no prior golf experience was defined as playing golf or golf-related activity (e.g., mini golf, top golf) once or twice a year at the most. The participants were approached by the researcher or signed up to participate through the university's participants pool to gain one credit. Participants were aged 24.37 years on average, mostly white (63.3%), and majoring in a sport science discipline (56.7%; see Table 1). Participants were randomly assigned to either the experimental (self-talk) or to the control condition, with 15 participants in each condition.

Insert Table 1 here

Apparatus

SensoMotoric Instruments (SMI) eye-tracker was used to measure quiet-eye durations. This device utilizes two features: the pupil and corneal reflection to calculate point of gaze at 60

Hz. A circular cursor, representing one degree of visual angle with 4.5 mm lens, indicating location of gaze in a video image. The video images were viewed by the researcher in real time using a Samsung Galaxy 4S, installed with iView ETG software, directly plugged to the eye-tracker. Recorded data was then transferred to a computer located in the lab (Alienware) installed with BeGaze 3.7 eye movement analyzing software, using a Secure Digital (SD) 64 gigabytes drive.

Measures

Quiet-eye Period. Quiet-eye periods were measured in milliseconds (ms) by using the SensoMotoric Instruments (SMI) eye-tracker. Quiet-eye period was operationally defined as the final fixation on the golf ball prior to the initiation of the backswing (Vickers, 2007). Onset occurred before the initiation of the backswing and offset occurred when the gaze was deviated off the fixated object (i.e., golf ball) by one degree or more for more than 100 ms. A fixation was defined as a gaze maintained on the golf ball within three degrees of visual angle for a minimum of 100 ms (Moore et al., 2012).

Putting Performance. Smith and Holmes's (2004) index of putting proficiency was used in the current study. According to this index, putts that landed on the hole representation scored five points, putts that landed on the lip of the hole representation (with control over their pace) scored three points, putts that went past or wide of the hole representation (with control over their pace) scored two points, and putts that landed short of the hole scored one point.

Intervention Check. Zourbanos et al's. (2013) intervention check was employed to measure the use of self-talk. The self-talk condition participants were asked to (a) indicate on a 10-point scale the degree to which they used the instructed cue, from 1 (*not at all*) to 10 (*all the* *time*), (b) report whether they used any other cue, (c) if so, to indicate what was the cue, and (d) the degree they used this other cue, from 1 (*not at all*) to 10 (*all the time*). The control condition participants were asked to (a) report whether they were thinking of something specific during the execution of the task, (b) if so, what thoughts, and; (c) if so, to what degree they used the cue from 1 (*not at all*) to 10 (*all the time*).

Procedure

Upon arrival to the lab, participants were briefed that they are about to take part in an experiment measuring their eye movement during a golf putting trial. They completed an informed consent form and demographic information via Qualtrics using a touchpad device. Participants were then familiarized with the standard-length golf club (35 inches), the putting green and the circular smooth (i.e., not sunken) hole representation (4.25 inches in diameter). They were given technical instructions on how to putt with an added prompt to try and keep their gaze on the ball throughout the putting movement (Pelz, 2000). Participants then performed a familiarization stage practice consisting of 10 putts, in which they were instructed to try landing the ball on the hole representation to the best of their ability. Following the familiarization stage, the eye-tracker was fitted and calibrated, and 5 additional putts were performed in order for participants to get accustomed to the eye-tracker and to check that the equipment was working properly. Participants then performed two sets of 10 consecutive putts in which their quiet-eye periods and the performance scores were recorded as baseline data. Participants were not given information on how putting performance was scored in order to prevent changes in the putting strategy.

Upon completion of the baseline measures, each participant was randomly assigned to the self-talk or control conditions. Using Hatzigeorgiadis et al's. (2007) protocol, participants who were assigned to the self-talk conditions underwent a brief explanation regarding the use of instructional self-talk. The explanation included a brief introduction to self-talk, stating that self-talk refers to any verbal cues we are giving to ourselves, whether out loud or in our mind, while we perform. The technique can be used to remind ourselves what we must do to calm ourselves and to keep us motivated. The participants were then told that the use of self-talk has been shown to improve performance. After the brief introduction, the participants were instructed to ask themselves three questions when they use self-talk: what, when and why. Specifically, "What" refers to what is the verbal cue being used, "when" refers to the timing in which the cue is used, and "why" refers to the reason the cue is used. They were then given the following example: in dart throwing you wish to focus on the center of the target because a hit closer to the center will give you more points. Thus, if you want to use self-talk to improve your dart throwing you might use the words "focus" or "target" as a cue. The cue could be used right before the throw, and the reason is to remind yourself to focus on the center of the target.

The explanation was followed by a dart throwing trial consisting of 10 sets of three consecutive dart throws, in which the participants were asked to use an instructional self-talk cue before each throw. To promote autonomy, participants were given a choice whether to use the self-talk cues given in the example or to create their own instructional self-talk cue, and whether to use the cue overtly or covertly (Hatzigeorgiadis et al., 2011). Following the dart throwing procedure, participants were asked to transfer the use of instructional self-talk to golf putting, using the "what, when, why" method. They were given an example how to apply instructional self-talk in golf putting, using the cues "focus" or "ball" before conducting each putt in order to remind themselves to focus on the golf ball. The control condition participants underwent the dart throwing trial without the self-talk component. The dart throwing trial was followed by another two sets of 10 putts while quiet-eye periods and performance were measured as post-intervention data. Before the putting session, the self-talk condition participants were asked to use an instructional self-talk cue during the trial. Administration of the intervention check and debriefing were then followed.

Statistical analysis

A frame-by-frame analysis was conducted to determine the quiet-eye period durations. Quiet-eye durations were computed to all putts in the pre and post-intervention sets. In addition, a summation of golf putting scores of both baseline and post intervention was calculated. SPSS 20 was used to analyze the data. Descriptive statistics, and condition differences in demographic variables were analyzed using χ^2 and independent t-tests. Means and standard deviations of the intervention checks were calculated. The assumptions of normality, homogeneity of variance, sphericity and homogeneity of inter-correlations were tested prior to the main analyses. The main analyses consisted of two repeated measures ANOVAs with two between conditions levels (self-talk vs. control), and two within conditions levels (pre vs. post). Quiet-eye durations and putting performance were used as two dependent variables. The ANOVAs were followed by post-hoc Bonferroni tests to conduct pairwise comparisons of the means in order to discern which comparisons were significant (Bonferroni correction of $p < .0125$). In addition, a serial mediation analysis was conducted using the MEMORE SPSS Macros (version 2.1) suite's model 1, with pre minus post-intervention performance as the outcome variable, and pre minus post-intervention quiet-eye durations as a mediating variable. The analysis included 5,000 bootstrap samples

Results

Separate Chi-square analyses failed to show condition differences for gender $\chi^2(1, N = 30) = .14$, $p = .71$, ethnicity, $\chi^2(3, N = 30) = 1.53$, $p = .68$, grade level, $\chi^2(5, N = 30) = 4.89$, $p = .43$, dominant hand, $\chi^2(1, N = 43) = 0.00$, $p = 1.00$, and age, $t(28) = .99$, $p = .33$. In addition, the assumptions of normality, homogeneity of variance, sphericity, and homogeneity of inter-correlations for both the quiet-eye duration and performance were not violated.

Intervention check

The intervention check means and standard deviations showed that participants in the self-talk condition made adequate use of self-talk ($M = 9.6$, $SD = .74$, $Min = 8$, $Max = 10$). In addition, five participants in the self-talk condition reported using another cue. Three of the participants reported using cues that relate to technical elements of the task (i.e., "keep the putter head open", "try to be smooth", and "bend the knees with frequencies of 10, 7 and 4" respectively). Another participant used the cue "go" before each putt. Lastly, one participant reported using a cue to reset and try again with the frequency of 6. The control intervention check revealed that six participants reported reoccurring thoughts while performing ($M = 7.67$, $SD = 1.51$, $Min = 6$, $Max = 10$). Further analysis showed that three participants reminded themselves to follow instructions in general ($min = 8$, $max = 10$), and three participants tried to focus on elements of the task or movement (i.e., the swing motion; keeping the knees bent; position of the club and hands with the frequencies of 6, 6, and 8 respectively). Since none of the control condition participants reported using instructional self-talk cues to remind themselves to focus on the ball, all participants were included in the subsequent analyses.

Main analyses

To test the effect of self-talk on quiet-eye durations, a 2x2 (condition x time) mixed-design ANOVA was conducted. A significant condition x time interaction effect emerged, $F(1, 28) = .41.71$, $p < .001$, $\eta_p^2 = .60$. A post hoc Bonferroni test revealed that that participants in self-talk condition fixated their gaze significantly longer (M = 2662.17ms, SD = 1542.85) than participants in the control condition (M = 937.31ms, SD = 958.68) in the post-intervention measurement (see Figure 1). No significant differences were observed prior to the interventions.

Insert Figure 1 here

A similar analysis with performance as a dependent variable resulted in a significant interaction effect of condition x time, $F(1, 28) = 13.72$, $p = .001$, $\eta_p^2 = .33$. A post-hoc Bonferroni test revealed that participants in the self-talk condition performed significantly better (M = 60, SD = 8.75) than the participants in the control condition (M = 53.8, SD = 7.15) in the post-intervention stage but not at the pre-intervention stage (see Figure 2).

Insert Figure 2 here

Lastly, a serial mediation analysis was conducted. The pre-post differences in performance and quiet-eye were computed. The analysis revealed a total model significant effect (pre – post performance *effect* = -5.23, *SE* = 1.33), $t(29) = -4.61$, $p < .001$, a significant indirect effect quiet-eye, *Effect* = -1.88, *Boot SE* = .81 (*CI:* -3.7 - -.54), and a significant direct effect of quiet-eye on performance, (*Effect* = -3.35, *SE* = 1.23), $t(28) = -2.72$, $p < .05$. In sum, the quiet-eye has both direct and indirect effect on performance, and can be considered a robust partial mediator in determining fine motor skills.

Discussion

The aim of the investigation was twofold; to replicate and extend evidence supporting the positive effect of strategic self-talk interventions on sport performance, and to investigate a perceptual-attentional mechanism underlying self-talk, namely the quiet-eye period. The results support the notion that even short-term self-talk interventions can be effective in increasing sport performance in the skill acquisition stage, and provide further evidence indicating that instructional self-talk is effective when executing fine motor movement tasks (Hatzigeorgiadis et al., 2011). In addition, the study provides initial direct evidence supporting the assumption that instructional self-talk serves as an attention allocation technique (Hatzigeorgiadis & Galanis, 2017). Lastly, the mediation analysis supported the notion that performance was mediated by longer quiet-eye durations. These results establish a positive link between self-talk, quiet-eye durations, and golf performance in novice players. In other words, it seems that instructional self-talk enhances performance by allocating attention to relevant environmental cues, and thus prolonging the duration of the quiet-eye period.

On a broader scope, self-talk can play a crucial role in the decision-making process, and the subsequent response execution during the skill acquisition stage. According to Tenenbaum's (2003) *Sport-Related Decision-Making Schema*, decision-making is derived mostly from relevant visual information in the environment. Self-talk use enables the performer to focus on relevant environmental cues before the execution of a task-oriented movement, and therefore promotes the processing of relevant information, which in turn, leads to more accurate decision-making and superior skill execution.

While not measured directly in this investigation, self-talk may promote other perceptual-attentional skills that are crucial to sport performance. Abernethy and Russel (1987) demonstrated that experts engage in visual search that is characterized by fewer fixations for longer durations on relevant environmental cues compared to novices. In addition, while the last gaze fixation before the execution of the movement, or quiet-eye period, is of the utmost importance for performance, gaze fixations during the movement (i.e., online quiet-eye) and after the completion of the movement (i.e., post quiet-eye) are crucial as well (Vickers, 2007).

Taking into consideration the stages of the *Sport-Related Decision-Making Schema,* gaze fixation before the execution of a movement is important for information processing and subsequent decision-making. Gaze fixation during the execution of the movement may be crucial for the execution and alteration of the movement. Lastly, gaze fixation on the relevant target after completing the movement can provide feedback that is relevant to the next performance trial. By using self-talk, the aforementioned perceptual-attentional skills can be affected as well. Therefore, future studies can take a more holistic approach to measuring gaze behavior and include the number of fixations on the relevant target, the duration of each fixation, and the components of online and post-quiet-eye periods in addition to the traditional quiet-eye durations. A comprehensive gaze behavior analysis could include quantifying every fixation on the target, the duration of fixation on the target from the beginning of the movement to the completion of the movement (online-quiet-eye), and the duration of fixation on the moving target after the movement completion (post-quiet-eye).

While the direct evidence supporting attention regulation as an underlying mechanism of self-talk provided in this study is compelling, it is imperative to reiterate that attention regulation is one of several underlying mechanisms (Galanis & Hatzigeorgiadis, 2020). The notion that self-talk enhances performance by promoting automaticity of movement was not explored in this study, and given that the participants were novices, it is safe to assume that automaticity was not obtained in such an early stage of skill acquisition. However, the attentional allocation attributes of self-talk can promote automaticity as well. Wulf et al. (1999) suggested that by focusing attention externally rather than internally, automatic execution of skills is promoted. By using self-talk to allocate attention to environmental cues, performers naturally focus their attention externally and not internally, and thus might maintain automaticity. Future studies are warranted to recruit intermediate or expert performers that already obtained automaticity of movement and employ certain technologies (e.g., motion analysis) to investigate whether self-talk promotes automatic responses alongside superior gaze behaviors.

Moreover, due to the participants’ skill level in the current study, no intervention was employed to imitate competition conditions (e.g., performing under pressure, mental fatigue or performance anxiety). While we took strides to ensure reasonable ecological validity in terms of the golf putting task, the psychological elements accompanying competition were not taken into consideration and might have affected the results. Stressful situations can affect perceptual-attentional mechanisms by narrowing attention and creating internal and external distractions (Jones & Hardy, 1989). Experimental evidence has supported the effectiveness of self-talk under adverse conditions, such as external distraction Galanis et al. (2018), ego depletion (Galanis, Nurkse, et al. 2022), and physical fatigue (Galanis, Papagiannis et al. 2022), however not in competitive environments. Therefore, we recommend examining the effect of self-talk on perceptual-attentional elements under ecologically valid competitive conditions in subsequent studies.

In the same vein, the golf putting task adopted in this study is self-paced in nature. Due to the limitations of eye-tracking technology, perceptual attentional studies mostly employ self-paced tasks like dart throwing (Vickers et al., 2000) and golf putting (Vine et al., 2014). Such tasks do not require performing complex motor sequences under time constraints and in dynamic environments. Certain sports require fast-pace decision-making under time limits and environmental distractors (e.g., football, basketball). Moreover, performing in such sports may require attention allocation to several environmental cues in order to get the necessary information needed to perform optimally. Therefore, in more dynamic sports, utilizing instructional self-talk to allocate attention focus on one specific environmental cue, might not be as effective as has been demonstrated in this study.

The partial mediation of the quiet-eye duration on performance leaves room for speculation regarding other mechanisms underlying performance in novice golfers. For instance, Gallachio and Ring (2020) suggested that longer durations of the quiet-eye are associated with postural stability. According to the *postural-kinematic hypothesis* the link between quiet eye and performance is accounted for by the stability of the trunk, limbs, head, and eyes. Thus, novice golfers with superior postural stability exhibit slower and more stable swings, and subsequently longer quiet eye durations. In addition, Bellomo et al. (2020) argued that a possible underlying mechanism of self-talk is that of increased top-down control of action. Specifically, novice golfers that underwent an instructional self-talk intervention demonstrated increased cortical and kinematic activity associated with top-down processes. Top-down processes are in turn associated with better learning and golfing technique development. Such processes can further explain the link between self-talk, quiet-eye durations and performance, and can be explored in future investigations.

It is worth noting that while the positive effect of self-talk on putting performance was replicated, the method used to measure performance in the current investigation raises some limitations that must be addressed. Specifically, a smooth hole representation was utilized instead of an actual putting hole. It is safe to assume that the hole representation affected the putting strategy the participants employed. While not directly instructed in that regard, the participants probably tried to make the ball land on the hole representation, and did not employ an overshoot strategy (i.e., hit the ball to go over the hole) typically used when putting into an actual hole. The fact that the participants in this study were considered novices, strengthens the notion that such overshoot strategy was not employed. Therefore, scoring the putts using the index of putting proficiency (Smith & Holmes, 2004), in which putts that go over or wide of the hole presentation earn more points than putts that fall short of the hole representation, might not be accurately representing the putting performance in this study.

Perhaps relating to that, no significant improvement was recorded after the intervention within the control condition participants. In fact, the control participants improved by one point only post-intervention. The lack of improvement within the control condition is not in line with other investigations that show performance improvements over time in the skill acquisition stage regardless of experimental condition (e.g., Perkos et al., 2002). In addition, participants in the self-talk condition performed better than controls by six points post-intervention on average according to the index of putting performance. While this margin is statistically significant, it does not necessarily represent better putting performance, especially when considering the aforementioned performance measurement limitations. Further studies must employ more precise putting performance assessments such as calculating the radial error of each putt, thus measuring the distance of the golf ball from the hole representation (e.g., Moore et al., 2012).

Lastly, some other conceptual and methodological limitations must be considered when interpreting the results. First, the effects of motivational or organic self-talk cues were not investigated. Motivational self-talk can lead to attentional benefits in dynamic situations by creating pleasant affect and increase self-efficacy (Chang et al., 2014). Future investigations might focus on more dynamic sport-related tasks, and incorporate strategic motivational self-talk interventions as well in order to explore the underlying mechanisms related to the different self-talk functions. In addition, the investigation of the effects of organic self-talk on attention allocation is crucial to holistically capture the self-talk phenomenon and its relationship with performance. Several organic self-talk functions have been identified, and their relations with performance and performance-related variables can indicate that the way athletes address themselves affect attention allocation (Zourbanos et al., 2009). Second, while the importance of conducting lab studies and investigating sport-related tasks was mentioned above, it is important to note some ecological validity limitations in the study. The study investigated students, was conducted in a lab setting, and participants wore eye-trackers, all of which might limit the applicability of the results to golf settings. Lastly, no retention test was conducted in the study, and therefore it is unclear if longer quiet-eye durations and enhanced performance were maintained over time. In the skill acquisition stage, self-talk may not be utilized in a retention test if participants are not prompted to use it. It also raises the question of the number of instructions that must be utilized to ingrain self-talk use as part of the overall skill acquisition (Schmidt, 1991).

In conclusion, despite the limitations, the current study reinforces the notion that strategic instructional self-talk interventions are effective in increasing performance of fine motor movement, and novel self-paced tasks. The increase in performance was evident partially through the perceptual-attentional mechanism of the quiet-eye period. Increasing the duration of the quiet-eye period leads to better information processing, decision-making, and response execution. Therefore, using self-talk cues with the aim of focusing on relevant environmental targets leads to increased performance through the underlying mechanism of the quiet-eye period. The results of the study encourage athletes, coaches and performance consultants to incorporate instructional self-talk cues in the skill acquisition stage in order to streamline the learning of novel, precision skills and acquire effective gaze behaviors.

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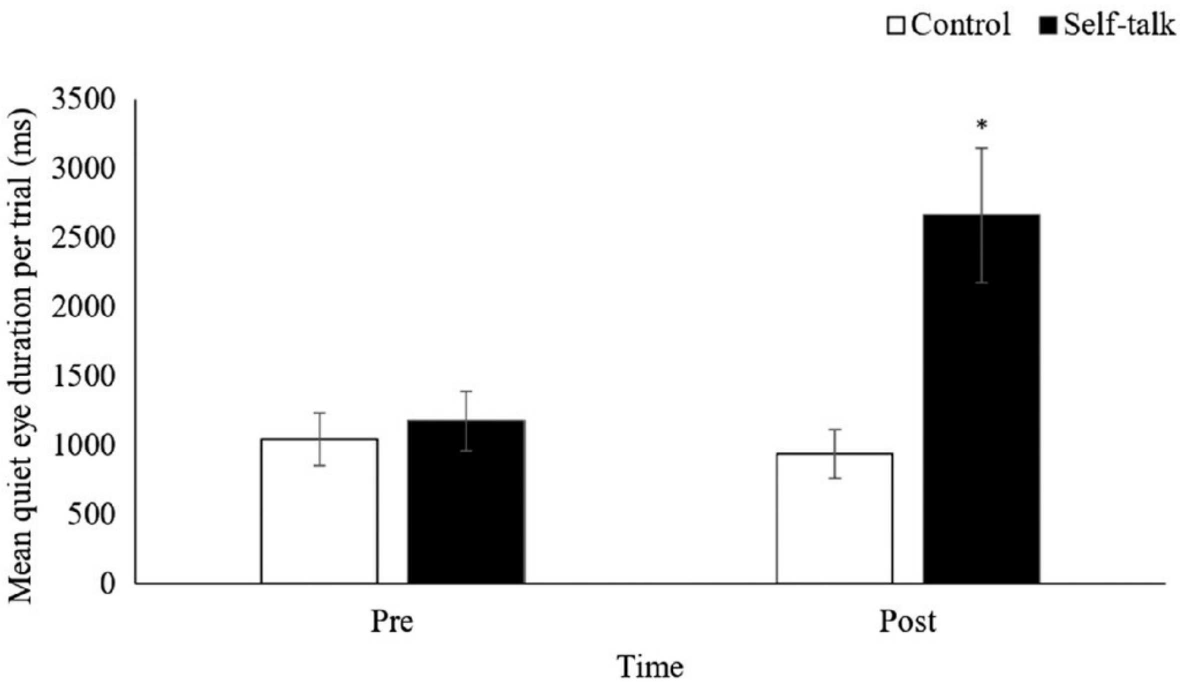
Table 1

Demographic information of the study's sample (N=30)

	Total	**Self-talk (N=15)**	**Control (N=15)**
Age in years M (SD)	24.37 (4.99)	25.27 (5.05)	23.47 (4.93)
Gender N (%)			
Male	17 (56.7)	9 (60)	8 (53.3)
Female	13 (43.3)	6 (40)	7 (46.7)
Ethnicity N (%)			
White	19 (63.3)	10 (66.7)	9 (60)
Asian	1 (3.3)	1 (6.7)	0 (0)
Hispanic	7 (23.3)	3 (20)	4 (26.7)
Black	3 (10)	1 (6.7)	2 (13.3)
Education N (%)			
Freshman	1 (3.3)	1 (6.7)	0 (0)
Sophomore	4 (13.3)	1 (6.7)	3 (20)
Junior	5 (16.7)	1 (6.7)	4 (26.7)
Senior	6 (20)	4 (26.7)	2 (13.3)
Graduate	11 (36.7)	6 (40)	5 (33.3)
Other	3 (10)	2 (13.3)	1 (6.7)
Major N (%)			
Sports science	17 (56.7)	8 (53.4)	9 (60)
Psychology	8 (26.6)	6 (40)	2 (13.3)
Other	5 (16.7)	1 (6.7)	4 (26.7)

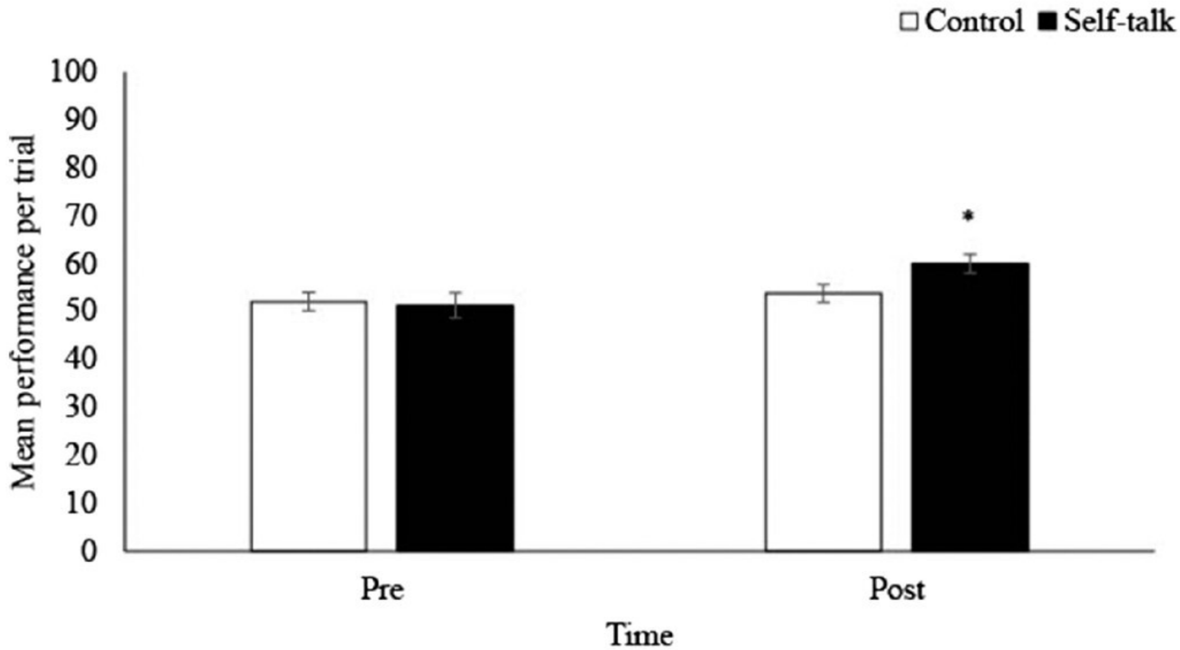
Figure 1



Note. Quiet eye durations are presented in milliseconds. Error bars represent SEs.

$^*p < .001$

Figure 2



Note. Putting performance scored from 1 (*short of the hole*) to 5 (*in the hole*) and aggregated. Error bars represent SEs. *$p < .001$.