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

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### **Performance**

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**12 The Effects of Instructional Self-Talk on Quiet-eye Duration and Golf Putting Performance****13 Abstract**

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

25           Self-talk refers to the phenomenon in which performers express verbal cues to themselves  
26 in order to regulate their performance or performance-related factors (Hardy, 2005). Self-talk can  
27 occur organically, and represents the internal dialogue of the performer (Latinjak et al., 2014). In  
28 addition, self-talk can be utilized strategically, in which case the performer uses deliberate verbal  
29 cues to promote behaviors, cognitions and emotions aimed at facilitating learning and enhancing  
30 performance (Fritsch et al., 2021). Athletes, coaches and performance consultants frequently use  
31 strategic self-talk interventions (Van Raalte et al., 1995), and such interventions have been  
32 deemed effective in enhancing performance in various sports (e.g., Perkos et al., 2002), exercise  
33 modes (e.g., Hatzigeorgiadis et al., 2018), and performance domains (e.g., Hoffman & Hanrahan,  
34 2012).

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

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

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

67           In contrast, attention regulation related to self-talk has not been sufficiently studied and  
68 its effect of performance was investigated only indirectly. Specifically, the use of strategic self-  
69 talk helped avoid auditory distractions while performing a computer task and a basketball free  
70 throw trial (Galanis et al., 2018). In addition, athletes reported fewer interfering thoughts after

71 participating in a strategic self-talk intervention (Hatzigeorgiadis et al., 2004). In a series of  
72 assessments using the Vienna Test System, participants that underwent a strategic self-talk  
73 intervention showed improved alertness, vigilance, focus, selective and divided attention  
74 (Galanis et al., 2022). While the aforementioned studies have provided useful preliminary  
75 insights regarding the attention regulating self-talk mechanisms through indirect or off-the-field  
76 evidence, research examining perceptual-attentional processes directly within a sport context is  
77 lacking. Towards this direction, a sport-specific attentional-cognitive framework was adopted in  
78 the present study. Tenenbaum's (2003) *Sport-Related Decision-Making Schema* suggests that  
79 performers' real-time decision making and response execution are dependent on perceptual-  
80 attentional processes and information processing. Specifically, performers attend to relevant cues  
81 in the environment, the information is then processed and allows the performers to decide on the  
82 best course of action to perform. The performers then execute the relevant movements and  
83 alternate them if needed when new information is processed. Lastly, the performers receive  
84 feedback from the environment after the execution of the skill, which they encode for future  
85 retrieval in similar situations. Therefore, gaze behavior plays a crucial role in sport-related  
86 decision-making and response execution, and one of the most prominent perceptual-attentional  
87 elements that relates to sport performance is the quiet-eye period.

88         The quiet-eye period is defined as the final gaze fixation on a task-related object or  
89 location for a minimum of 100 milliseconds and within 3 degrees of visual angle prior to the  
90 initiation of the movement (Vickers, 2021). It is theorized that the quiet-eye period represents the  
91 time needed to organize the neural structures that control the visual and motor systems (Dalton,  
92 2021). Therefore, during the quiet-eye period, the most relevant and up-to-date information is  
93 being gathered to assist the performer to execute the designated decision. Research has shown

94 that longer quiet-eye durations are associated with better performance (Land, 2009). The relation  
95 between quiet-eye durations and increased performance has been demonstrated in several self-  
96 paced sports and tasks including dart throwing (Vickers et al., 2000), billiards (Williams et al.,  
97 2002), penalty kicks (Piras & Vickers, 2011), and golf putting (Vine et al., 2014). A meta-  
98 analysis of 27 studies reinforces the quiet-eye and performance correlation and associates longer  
99 quiet-eye durations with higher level of expertise (Lebeau et al., 2016). In addition, in a brain  
100 imaging study, a strong correlation was recorded between quiet-eye durations and readiness-  
101 potential activation, which is an indication of information processing before the execution of a  
102 movement. Therefore, visually attending to relevant cues, leads to better information processing,  
103 which in turn leads to superior decision-making and execution (Mann et al., 2011).

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

117 we maintain that instructional self-talk cues can be used to regulate attention to a relevant  
118 environmental cue (i.e., the golf ball), and therefore lead to longer quiet-eye durations and better  
119 performance.

## 120 **The Current Study**

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

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

135 The current study was a randomized – controlled trial with a mixed between (self-talk vs.  
136 control) within (pre- vs. post-intervention) design. Considering the extant literature regarding the  
137 effectiveness of strategic self-talk and its postulated attention regulating mechanism, it was  
138 expected that the participants in the self-talk condition will display better performance and



139 longer quiet-eye durations than participants in the control condition post-intervention. In  
140 addition, quiet-eye durations were expected to mediate performance.

## 141 **Method**

### 142 **Participants**

143 An a priori power analysis for a mixed-design ANOVA was conducted using GPower  
144 version 3.1 (Faul et al., 2009) with a moderate effect size reported by Hatzigeorgiadis et al.'s  
145 (2011) meta-analysis. Accordingly,  $\bar{d} = .55$ ,  $\alpha = .05$ ,  $power (1 - \beta) = .80$ , .5 correlation among  
146 repeated measures, no sphericity correction of 1, two between conditions factor (self-talk vs.  
147 control), and two within conditions factor (pre vs. post) were used for the power analysis. The  
148 recommended sample size was 30 participants. Therefore, a convenience sample of 30  
149 participants was recruited. The inclusion criteria were little to no prior golf putting experience  
150 and the ability to hold and swing a golf club. The inclusion criterion of little to no prior golf  
151 experience was defined as playing golf or golf-related activity (e.g., mini golf, top golf) once or  
152 twice a year at the most. The participants were approached by the researcher or signed up to  
153 participate through the university's participants pool to gain one credit. Participants were aged  
154 24.37 years on average, mostly white (63.3%), and majoring in a sport science discipline (56.7%;  
155 see Table 1). Participants were randomly assigned to either the experimental (self-talk) or to the  
156 control condition, with 15 participants in each condition.

157 **Insert Table 1 here**

### 158 **Apparatus**

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

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

## 167 **Measures**

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

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

180 **Intervention Check.** Zourbanos et al's. (2013) intervention check was employed to  
181 measure the use of self-talk. The self-talk condition participants were asked to (a) indicate on a  
182 10-point scale the degree to which they used the instructed cue, from 1 (*not at all*) to 10 (*all the*

183 *time*), (b) report whether they used any other cue, (c) if so, to indicate what was the cue, and (d)  
184 the degree they used this other cue, from 1 (*not at all*) to 10 (*all the time*). The control condition  
185 participants were asked to (a) report whether they were thinking of something specific during the  
186 execution of the task, (b) if so, what thoughts, and; (c) if so, to what degree they used the cue  
187 from 1 (*not at all*) to 10 (*all the time*).

## 188 **Procedure**

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

204       Upon completion of the baseline measures, each participant was randomly assigned to the  
205 self-talk or control conditions. Using Hatzigeorgiadis et al's. (2007) protocol, participants who

206 were assigned to the self-talk conditions underwent a brief explanation regarding the use of  
207 instructional self-talk. The explanation included a brief introduction to self-talk, stating that self-  
208 talk refers to any verbal cues we are giving to ourselves, whether out loud or in our mind, while  
209 we perform. The technique can be used to remind ourselves what we must do to calm ourselves  
210 and to keep us motivated. The participants were then told that the use of self-talk has been shown  
211 to improve performance. After the brief introduction, the participants were instructed to ask  
212 themselves three questions when they use self-talk: what, when and why. Specifically, “What”  
213 refers to what is the verbal cue being used, “when” refers to the timing in which the cue is used,  
214 and “why” refers to the reason the cue is used. They were then given the following example: in  
215 dart throwing you wish to focus on the center of the target because a hit closer to the center will  
216 give you more points. Thus, if you want to use self-talk to improve your dart throwing you might  
217 use the words “focus” or “target” as a cue. The cue could be used right before the throw, and the  
218 reason is to remind yourself to focus on the center of the target.

219         The explanation was followed by a dart throwing trial consisting of 10 sets of three  
220 consecutive dart throws, in which the participants were asked to use an instructional self-talk cue  
221 before each throw. To promote autonomy, participants were given a choice whether to use the  
222 self-talk cues given in the example or to create their own instructional self-talk cue, and whether  
223 to use the cue overtly or covertly (Hatzigeorgiadis et al., 2011). Following the dart throwing  
224 procedure, participants were asked to transfer the use of instructional self-talk to golf putting,  
225 using the “what, when, why” method. They were given an example how to apply instructional  
226 self-talk in golf putting, using the cues “focus” or “ball” before conducting each putt in order to  
227 remind themselves to focus on the golf ball. The control condition participants underwent the  
228 dart throwing trial without the self-talk component. The dart throwing trial was followed by

229 another two sets of 10 putts while quiet-eye periods and performance were measured as post-  
230 intervention data. Before the putting session, the self-talk condition participants were asked to  
231 use an instructional self-talk cue during the trial. Administration of the intervention check and  
232 debriefing were then followed.

### 233 **Statistical analysis**

234 A frame-by-frame analysis was conducted to determine the quiet-eye period durations.  
235 Quiet-eye durations were computed to all putts in the pre and post-intervention sets. In addition,  
236 a summation of golf putting scores of both baseline and post intervention was calculated. SPSS  
237 20 was used to analyze the data. Descriptive statistics, and condition differences in demographic  
238 variables were analyzed using  $\chi^2$  and independent t-tests. Means and standard deviations of the  
239 intervention checks were calculated. The assumptions of normality, homogeneity of variance,  
240 sphericity and homogeneity of inter-correlations were tested prior to the main analyses. The main  
241 analyses consisted of two repeated measures ANOVAs with two between conditions levels (self-  
242 talk vs. control), and two within conditions levels (pre vs. post). Quiet-eye durations and putting  
243 performance were used as two dependent variables. The ANOVAs were followed by post-hoc  
244 Bonferroni tests to conduct pairwise comparisons of the means in order to discern which  
245 comparisons were significant (Bonferroni correction of  $p < .0125$ ). In addition, a serial mediation  
246 analysis was conducted using the MEMORE SPSS Macros (version 2.1) suite's model 1, with  
247 pre minus post-intervention performance as the outcome variable, and pre minus post-  
248 intervention quiet-eye durations as a mediating variable. The analysis included 5,000 bootstrap  
249 samples

## 250 **Results**

251 Separate Chi-square analyses failed to show condition differences for gender  $\chi^2(1, N =$   
252  $30) = .14, p = .71$ , ethnicity,  $\chi^2(3, N = 30) = 1.53, p = .68$ , grade level,  $\chi^2(5, N = 30) = 4.89, p =$   
253  $.43$ , dominant hand,  $\chi^2(1, N = 43) = 0.00, p = 1.00$ , and age,  $t(28) = .99, p = .33$ . In addition, the  
254 assumptions of normality, homogeneity of variance, sphericity, and homogeneity of inter-  
255 correlations for both the quiet-eye duration and performance were not violated.

### 256 **Intervention check**

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

### 271 **Main analyses**

272 To test the effect of self-talk on quiet-eye durations, a 2x2 (condition x time) mixed-  
273 design ANOVA was conducted. A significant condition x time interaction effect emerged,  $F(1,$   
274  $28) = .41.71, p < .001, \eta_p^2 = .60$ . A post hoc Bonferroni test revealed that that participants in self-  
275 talk condition fixated their gaze significantly longer ( $M = 2662.17\text{ms}, SD = 1542.85$ ) than  
276 participants in the control condition ( $M = 937.31\text{ms}, SD = 958.68$ ) in the post-intervention  
277 measurement (see Figure 1). No significant differences were observed prior to the interventions.

278 Insert Figure 1 here

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

284 Insert Figure 2 here

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

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**Discussion**

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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.

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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.

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316

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)



317 demonstrated that experts engage in visual search that is characterized by fewer fixations for  
318 longer durations on relevant environmental cues compared to novices. In addition, while the last  
319 gaze fixation before the execution of the movement, or quiet-eye period, is of the utmost  
320 importance for performance, gaze fixations during the movement (i.e., online quiet-eye) and after  
321 the completion of the movement (i.e., post quiet-eye) are crucial as well (Vickers, 2007).

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

335         While the direct evidence supporting attention regulation as an underlying mechanism of  
336 self-talk provided in this study is compelling, it is imperative to reiterate that attention regulation  
337 is one of several underlying mechanisms (Galanis & Hatzigeorgiadis, 2020). The notion that  
338 self-talk enhances performance by promoting automaticity of movement was not explored in this  
339 study, and given that the participants were novices, it is safe to assume that automaticity was not

340 obtained in such an early stage of skill acquisition. However, the attentional allocation attributes  
341 of self-talk can promote automaticity as well. Wulf et al. (1999) suggested that by focusing  
342 attention externally rather than internally, automatic execution of skills is promoted. By using  
343 self-talk to allocate attention to environmental cues, performers naturally focus their attention  
344 externally and not internally, and thus might maintain automaticity. Future studies are warranted  
345 to recruit intermediate or expert performers that already obtained automaticity of movement and  
346 employ certain technologies (e.g., motion analysis) to investigate whether self-talk promotes  
347 automatic responses alongside superior gaze behaviors.

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

360         In the same vein, the golf putting task adopted in this study is self-paced in nature. Due to  
361 the limitations of eye-tracking technology, perceptual attentional studies mostly employ self-  
362 paced tasks like dart throwing (Vickers et al., 2000) and golf putting (Vine et al., 2014). Such

363 tasks do not require performing complex motor sequences under time constraints and in dynamic  
364 environments. Certain sports require fast-pace decision-making under time limits and  
365 environmental distractors (e.g., football, basketball). Moreover, performing in such sports may  
366 require attention allocation to several environmental cues in order to get the necessary  
367 information needed to perform optimally. Therefore, in more dynamic sports, utilizing  
368 instructional self-talk to allocate attention focus on one specific environmental cue, might not be  
369 as effective as has been demonstrated in this study.

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

383         It is worth noting that while the positive effect of self-talk on putting performance was  
384 replicated, the method used to measure performance in the current investigation raises some  
385 limitations that must be addressed. Specifically, a smooth hole representation was utilized

386 instead of an actual putting hole. It is safe to assume that the hole representation affected the  
387 putting strategy the participants employed. While not directly instructed in that regard, the  
388 participants probably tried to make the ball land on the hole representation, and did not employ  
389 an overshoot strategy (i.e., hit the ball to go over the hole) typically used when putting into an  
390 actual hole. The fact that the participants in this study were considered novices, strengthens the  
391 notion that such overshoot strategy was not employed. Therefore, scoring the putts using the  
392 index of putting proficiency (Smith & Holmes, 2004), in which putts that go over or wide of the  
393 hole presentation earn more points than putts that fall short of the hole representation, might not  
394 be accurately representing the putting performance in this study.

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

406         Lastly, some other conceptual and methodological limitations must be considered when  
407 interpreting the results. First, the effects of motivational or organic self-talk cues were not  
408 investigated. Motivational self-talk can lead to attentional benefits in dynamic situations by

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

426 In conclusion, despite the limitations, the current study reinforces the notion that  
427 strategic instructional self-talk interventions are effective in increasing performance of fine  
428 motor movement, and novel self-paced tasks. The increase in performance was evident partially  
429 through the perceptual-attentional mechanism of the quiet-eye period. Increasing the duration of  
430 the quiet-eye period leads to better information processing, decision-making, and response  
431 execution. Therefore, using self-talk cues with the aim of focusing on relevant environmental

432 targets leads to increased performance through the underlying mechanism of the quiet-eye  
433 period. The results of the study encourage athletes, coaches and performance consultants to  
434 incorporate instructional self-talk cues in the skill acquisition stage in order to streamline the  
435 learning of novel, precision skills and acquire effective gaze behaviors.

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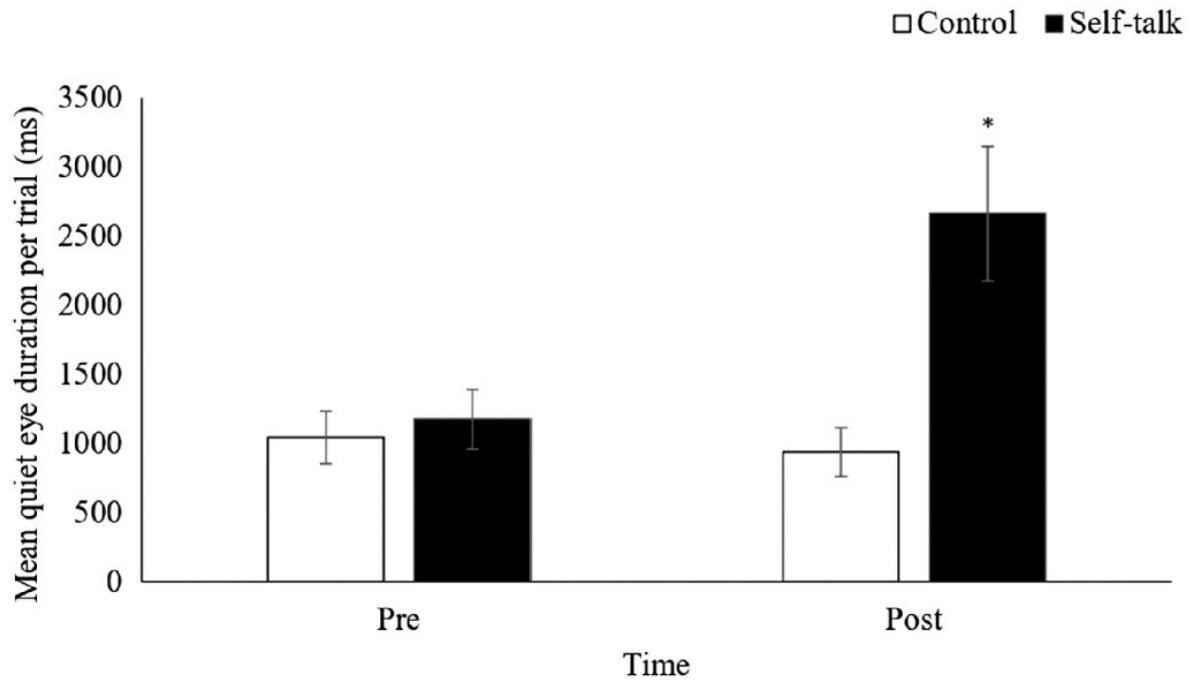
587 Table 1

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

	<b>Total</b>	<b>Self-talk (N=15)</b>	<b>Control (N=15)</b>
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)

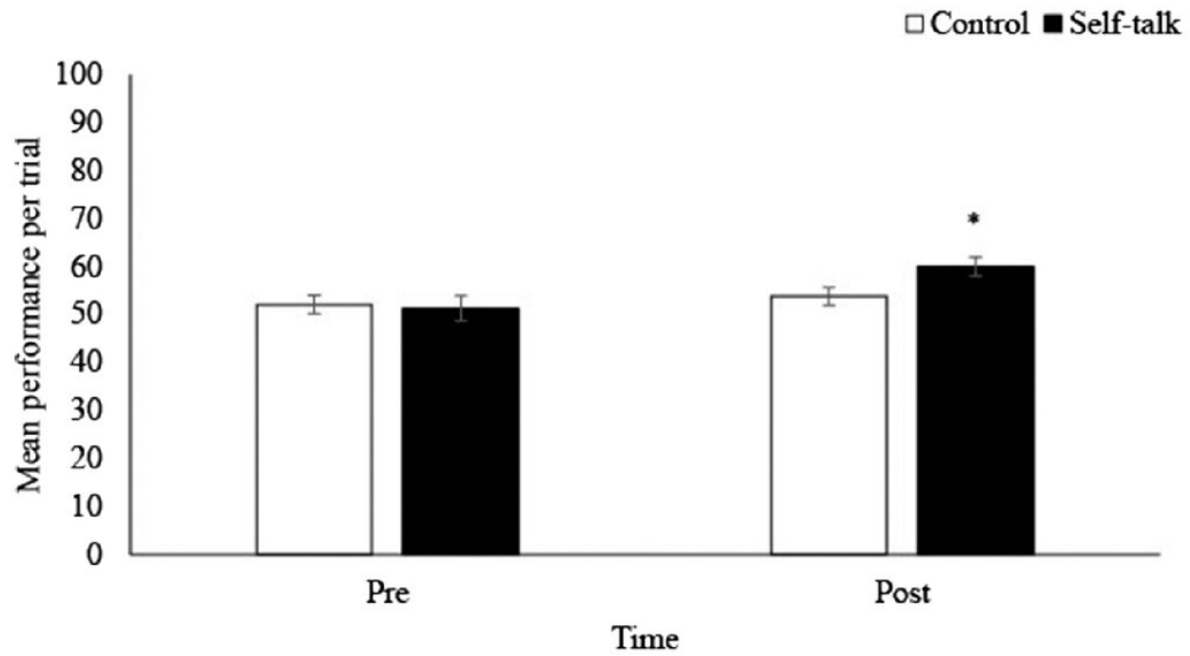
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591 **Figure 1**

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593 *Note.* Quiet eye durations are presented in milliseconds. Error bars represent SEs.594 \* $p < .001$

595 **Figure 2**

596

597 *Note.* Putting performance scored from 1 (*short of the hole*) to 5 (*in the hole*) and aggregated.598 Error bars represent SEs. \* $p < .001$ .