Target versus Ball Focused Aiming when Golf Putting: What has been done and what has been missed

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Abstract

As the prevalence of target focussed aiming in golf putting increases amongst professionals and amateurs alike, it is important to understand its operation *if* the synergy between research and practice is to be optimised. Therefore, the current paper's aims were firstly to review and critique existing empirical literature. Although our observations of these studies were informative, however, we identified a number of key methodological *inconsistencies* and *omissions*, which limits our understanding as a complete evidence-base across studies. Consequently and secondly, we provide insight into possible mechanisms for how target focussed aiming might work with corresponding measures for investigating these suggestions. Finally, we propose a number of methodological considerations that need to be addressed by future research. It is hoped this research will inform future practice when coaching the skill of putting.

Keywords: coaching, electroencephalography, gaze behaviour, intention/attention, visual aiming

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For closed and self-paced skills, technique plays an important role. As such, it is unsurprising that much research and practical instruction is dedicated to understanding how athletes move (e.g., Bartlett, 2007; Blazevich, 2012). One domain characterised by this focus is golf (e.g., Keogh & Hume, 2012; Meister et al., 2011), where differences between techniques are widely compared and evaluated amongst coaches (McHardy, Pollard & Bayley, 2006; Rodgers, Reade & Hall, 2007; Smith et al., 2015). In contrast, however, less *critical* attention has been applied to the relationship between perceptual processes and the effective selection, then execution, of an appropriate motor strategy (e.g., Hatfield, Haufler, Hung & Spalding, 2004; Nieuwenhuys & Oudejans, 2012; Schmidt, 1975). This is unfortunate since there is an obvious demand on the interaction between these processes during, for example, the task of putting. In this particular context, golfers must be able to accurately identify and utilise several factors, including target location and distance, surface topography and speed, in determining swing parameters such as aim direction and swing velocity. Accordingly, it is interesting that recent performances of some professional golfers (e.g., Major champions Jordan Speith and Louis Oosthuizen) have demonstrated much success in using a technique that challenges the perceived wisdom to “keep your eyes over the ball during execution” (hereafter termed ball focused aiming; BFA). Rather, these golfers putt whilst orienting their head, neck and visual field toward the target location during execution (hereafter termed target focused aiming: TFA, Figure 1). Such observations *of* sport (cf. Collins & Kamin, 2012) present challenge to fundamental understanding that is often developed *through* sport (e.g., Moore, Vine, Cooke, Ring & Wilson, 2012; Steinberg, Frehlich & Tennant, 1995; Vickers, 2012). Of course, as practitioners we are ultimately concerned with developing understanding *for* sport; in short, translational research. Crucially, decision making is understood to be an important part of coaching practice, which this paper aims to fundamentally inform (Abraham & Collins, 2011); both procedural ("how to do it") and declarative ("what needs to be done and why"), so an understanding of both parameters is important within this process. Therefore, in an attempt to support such decision making processes, the purpose of this paper is threefold. Firstly, we review and critique existing empirical literature on TFA; secondly, we offer potential perspectives to explain how TFA works and appropriate measures that could be used to illuminate such understanding, and; thirdly, we propose recommendations for future research to address aiming strategies in golf putting.

Existing Research: What has been done

Reflecting the aforementioned scarcity of research on TFA in golf, this section reviews the existing empirical evidence-base that *has* attempted to address this process. As a brief overview of effects, it is important to recognise that most studies have examined the impact of TFA on performance, with only MacKenzie, Foley and Adamczyk (2011) reporting process measures of putter head kinematics. Overall, findings are mixed. Some studies have shown performance improvement when using TFA (e.g., Alpenfels, Christina & Heath, 2008), others a disadvantage (e.g., Gonzalez, Kegel, Ishikura & Lee, 2012; Wannebo & Reeve, 1984) and others have shown no difference at all compared to BFA (e.g., Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988). For process measures relating to putter head kinematics, the main difference appears in the level of consistency between strokes, with TFA affording lower variability between trials for putter speed at impact. As yet, however, kinematics of the golfer's body is unreported within the literature (see Table 1 for a summary of the studies in greater detail).

Notably, for any programme of investigation to be coherent, it is crucial for experimental features to be resolutely combined with controlled variations from one study to the next (cf. Goginsky & Collins, 1996) as understanding of the phenomenon in question develops. However, such a chain between studies appears to be lacking on this topic, as evidenced by several inconsistencies and omissions. Accordingly, these are explored in order to provide a clearer overall picture of what has been done so far. It is also worth acknowledging the timescales over which these studies have been conducted; the earliest of eight studies being published in 1968. With this in mind, it is not our intention to be unfairly critical of this research (considering the obvious advances in technology plus the increased sociocultural value placed on applied research etc. over this period) but rather, to use the review as a process for identifying elements that would need to be addressed if we are to move forward in the present day, presenting a clear chain of methodological progression to feed into coaching practice.

****Insert Table near here****

Inconsistencies within Existing Research

Participants. Despite much research into expert–novice differences with respect to golf putting in general (e.g., Hasegawa, Fujii, Miura & Yamamoto, 2017; Taylor & Shaw, 2002), there has been a lack of comparison between these skill levels when employing the different putting methods (i.e., BFA vs. TFA). Studies within Table 1 were mostly conducted on novice golfers with no golfing experience; largely learning studies with little transferability to experienced and/or elite-level golfers. Typically, participants were university students classified as beginner golfers (Aksamit & Husak, 1983; Bowen, 1968; Cockerill, 1978; Gott & McGown, 1988; Wannebo & Reeve, 1984). Only three studies (Alpenfels et al., 2008; MacKenzie et al., 2011; Wannebo & Reeve, 1984) used active golfers (handicaps 8–36) and only one (Cockerill, 1978) used participants described as "elite amateur golfers" (handicap < 6; p. 379). Notably, Wannebo and Reeve (1984) and Gonzalez et al. (2012) distinguish their participant groups by years of 'experience' to infer skill level that, we suggest, is not the same thing and, therefore, potentially misleading (see Carson & Collins, 2016a). Handicap is a measure for grading amateur golfers but genuine novices will, by definition, not have one—beginner golfers typically have insufficient experience to achieve an accurate handicap. Moreover, handicap rates golfers' overall performance rather than just their putting skill (Robertson, Gupta, Kremer & Burnett, 2015).

An important lack of interrelation between handicap and putting skill is illustrated by professional golf tour rankings, whereby overall and putting rankings are not always the same (e.g., the 2015 European Tour Order of Merit winner was ranked 18 on putts per green in regulation and the number 1 ranked golfer on putts per green in regulation was ranked 171 overall). However, the handicap systems (USGA and R&A) are the globally recognised measure of an amateur golfer's skill level and should be used (when available) to inform the reader. Whilst it may be accepted that the 'low skilled' group described by Wannebo and Reeve (1984) and Gonzalez et al. (2012) might not have had an official handicap to report, failure of the authors to omit the 'highly skilled' groups' handicap level is a factor that should have been addressed to inform future research.

Returning to the overall picture, there are several potential confounds to the results obtained. Since the majority of participants tested were nongolfers, their performance could have depended on a number of factors, including: confidence levels, motivation to engage in the task, consistency (or lack thereof) of putting stroke, green reading ability and ability to align the club with the ball. Another possible limitation of the studies was participants' limited understanding toward the vision strategy of elite golfers. To be clear, the visual strategy of elite golfers includes *all* gaze behaviours prior to the final fixation on the ball, such as pursuits and saccades where both the duration and location of these gaze behaviours have been suggested to be important for putting performance (Vickers, 2012). Therefore, studies that used non-elite golfers in Table 1 may not have undertaken a robust test of comparisons between the two methods.

Furthermore, the papers cited gave no mention of participants' ocular dominance prior to testing. Ocular dominance is an essential visual component of aligning the ball with the target and the club with the ball (Farnsworth, 1997). According to Steinberg et al. (1995), ocular dominance impacts on putting accuracy. Their analysis indicated a significant interaction for dextrality and the relative position of the eyes during putting. *Pure dextral* (defined as symmetry in eye and hand) golfers demonstrated significantly less absolute error (10.65 cm ± 2.1 vs. 8.98 cm ± 2.5) and less variable error (11.76 cm ± 1.85 vs. 9.99 cm ± 2.44) in their putting performance from a distance of 3.66 m when they positioned their eyes midway between the ball and their feet compared to when they positioned their eyes directly over the ball. In practice, testing gaze behaviour, vision and green reading (determining the target line and distance) requires the use of stereopsis (the perception of depth produced by the reception in the brain of visual stimuli from *both* eyes), which is, in turn, affected by visual acuity. Notably, no studies within Table 1 referred to participants being visually examined for normal or corrected vision (e.g., a need for glasses or contact lenses) during the trials. Once again, this circumstance is not ideal for generating a 'state of the nation' consensus on the topic.

Equipment. The impact of golf club custom fitting has been shown to significantly improve club head speed, speed variability and tempo amongst novice golfers (Bertram & Guadagnoli, 2008), as well as being common practice nowadays within the applied setting. Due to the optimum putter loft varying as a function of the friction coefficient on any given putting green (i.e., in major part resulting from the grass length), putter length and lie angle are the two most prioritised aspects when conducting a putter fitting (Swash, 2016). The golfer's height and eye dominance (see previous section) are both important in determining these two outcomes. However, Aksamit and Husak (1983), Bowen (1968) and Cockerill (1978) all used standardised or centre shafted putters. In contrast, Wannebo and Reeve (1984) gave participants the option of using their own putter or, again, a putter supplied (i.e., standardised), while MacKenzie et al. (2011) used a Nike Unitized Retro putter (35" length) and Gonzalez et al. (2012) used a Ping Anser putter (length was not reported) across all participants. These inconsistencies make it difficult, if not impossible, to replicate or extend the experimental design. Furthermore, we must be sceptical about using standardised putters since evidence suggests that use of a 'distorted' putter leads to suboptimal performance for both novices *and* experts (Experiment 2; Beilock & Carr, 2001). While Beilock and Carr used a purposefully designed 'funny putter', we (the first author being a highly skilled amateur and third author a PGA Professional golf coach) recommend that similar discomfort can also occur when a putter merely feels or looks 'unfamiliar' (the latter notably not an issue during TFA), with length of shaft being a major contributor to this by altering the posture and degree of flexion at the elbows.

The type of golf balls used in the research was also inconsistent. For example, Wannebo and Reeve (1984) used nonconforming (for competitive play) driving range balls that would have different features such as compression (determined by the hardness of the core) and spin rate. These differences can be substantial, producing different dynamics to that of a conforming ball and could therefore have impacted on the results, or at the very least our ability to make accurate comparisons between different studies (Monk, Davis, Strangwood & Otto, 2004). Moreover, one must also consider the impact of unfamiliarity toward this type of golf ball for putting; it is more usual for golfers to execute full shots with a driving range ball on a driving range, or course. A Dunlop 65 ball was used in the Cockerill (1978) study which is a smaller sized ball (4.11 cm diameter) compared to that of the universally (both US and R&A rules) conforming ball since 1990 of 4.26 cm diameter. MacKenzie et al. (2011) used an approved R&A/USGA conforming ball (Callaway *Tour* i) and Gonzalez et al. (2012) also used a conforming ball (Titleist NXT). Unfortunately, there was no record of ball type used in Alpenfels et al. (2008). However, R. Christina (personal communication, June 20, 2016) has since confirmed the use of a conforming ball (Titleist Pro V1). As a minimum, we must be cautious about data from studies using nonconforming equipment (according to modern regulations) if they are to inform practice under different modern task constraints.

Nature of the dependent variable. In determining the effect of different experimental manipulations it is important to know the sensitivity of measures employed. For golfers and their coaches it is meaningful to know whether new training practices have been able to show an increase in putts holed or simply whether putts are missed to a lesser extent. Within the medical domain this may be similar to knowing whether a treatment merely slows down the progression of a disease *or* is a genuine option for cure. Certainly, and again, reflecting our point that inconsistency between studies makes it difficult to ascertain a consensus about the effect of TFA versus BFA, some studies have measured the number of putts holed (e.g., Cockerill, 1978; MacKenzie et al., 2011) and others the actual final distance from the ball to hole after each trial (e.g., Aksamit & Husak, 1983). However, even when the final distance to the hole is measured, Fischman (2015) stresses that exact measurements can be of varied usefulness. Specifically, when referring to the use of concentric circles around a target (as is commonly used for aiming studies) with assigned points for landing an object within each circular 'zone', Fischman points out that despite the same score being possible on two or more trials, the location is often ignored with respect to understanding performance differences. As such, future studies must be careful even when reporting on simple measures of displacement.

Experience with employing TFA. Considering that experts are known to improve their skill, even *if* by small amounts, following increased experience (Crossman, 1959), it is important to note that TFA studies provide a varied (and potentially insufficient) amount of time for participants to practice this new putting method. Indeed, this is particularly so for studies using active golfers who, by comparison, would have amasses many more hours of practice with the BFA method. For example, MacKenzie et al. (2011) conducted pre and posttests with a 4 week practice period in between, Gott and McGown (1988) used an alternative practice–test schedule for a period of 8 weeks and Alpenfels et al. (2008) collected all data within a single session. Therefore, it is difficult to compare effects across studies conducted. In practice coaching is, ideally (although we acknowledge that some athlete–coach relationships serve more specific and short-term purposes), operationalised longitudinally. Golfers are often permitted weeks, sometimes months (Carson & Collins, 2015), to work on developing their skills. Accordingly, it would be most revealing to demonstrate effects over greater (but more frequent) timescales as a depiction of players' reality, for both novices and active golfers.

Environmental context. Finally, to be able to evaluate research findings *for* use in golf (cf. Collins & Kamin, 2012), it is important that the environmental context holds sufficient ecological validity. Unfortunately, several of the studies to date were completed within an indoor laboratory setting (see Drane, Duffy, Fournier, Sherwood & Breed, 2014, for more on artificial turf–ball interaction conditions) rather than on the ground conditions experienced on an actual golf course (Bowen, 1968; Gonzalez et al., 2012; Gott & McGown, 1988; MacKenzie et al., 2011). We are not suggesting laboratory experiments are not useful (Berkowitz & Donnerstein, 1982; Christina, 1987), merely highlighting their fundamental drive to test causal hypotheses.

Moreover, the trials generally consisted of straight or flat putting tasks (Alpenfels et al., 2008; Cockerill, 1978; Gott & McGown, 1988; MacKenzie et al., 2011; Wannebo & Reeve, 1984) with the distance and direction of tasks insufficiently varied to truly represent golf putting. For instance, Cockerill (1978) tested putts of only 1 and 2 m in length whereas Alpenfels et al. (2008) covered a range of both short (3ft–8ft) and long (20ft–40ft) distances. Typically, putts will vary in length *and* have a slope and/or break to them, with a straight or flat putt being a rarity on a natural putting green. Indeed, the recently proposed *mesh* theory by Christensen, Sutton and McIlwain (2016) explains a differential level of control applied by performers depending on the task demands. When the task is very straightforward, and the performer has amassed plenty of experience at it, an automatic, effortless, fluid and attentionally undemanding state is possible for successful execution. However, Christensen et al. put the case forward that these do not characterise most sporting situations (see also Toner & Moran, 2015), despite experimental research depicting them as so. In such instances, performers may successfully complete the task by consciously applying attentional resources to key elements of their strategy. Carson and Collins (2016a) extended this work by explaining that it depends on *what* and *how* this attention is allocated that determines whether self-foci are either positive or negative toward the task (cf. Masters, 1992; Wulf, 2013). Consequently, a frequent lack of ecological validity raises doubt over the confidence with which we may say that TFA *is* better than BFA *or* indeed a viable alternative that should be introduced within golf coaching. Of course, fundamental research can offer many benefits (cf. Christina, 1987); however, more ecologically valid environments and tasks *must* be used if we are to further our understanding of the processes involved in, and effectiveness of, TFA in the real-world. Considering the limited number of studies conducted on TFA, we suggest that these inconsistencies further reduce the power of conclusions made regarding its effect. In short, at present we cannot know for sure what benefits, if any, exist.

Omissions within Current Research

When studies are designed and executed relative to previous literature, it creates a well-constructed expansion of knowledge. Although the strengths of the previous research do outweigh the criticisms, we will now highlight several important omissions.

Examination of robustness under high-anxiety conditions. With the exception of Gott and McGown (1988), who provided weekly rewards for consistent effort to participants for holing the most putts in practice, no other studies included a competitive and/or pressured situation into their experimental designs. In fact, it is questionable as to whether the rewards provided by Gott and McGown even promoted high levels of anxiety over such timescales. Certainly no data were reported to confirm that this was the case, nor do they state promoting high anxiety as their intention. This is an important omission if we are to translate empirical findings into effective coaching practice and performance. High-anxiety conditions are an almost inevitable feature of representative competitive sport (see Christensen et al., 2016) that coaches and athletes *should* address within their training, although this appears to be underaddressed as a proactive process in some golfing situations (Carson, Collins & MacNamara, 2013).

We are not saying that other golf skills do not require security under the most testing of conditions; they do. However, to illustrate such a point within the context of our paper's target focus, consider the cases of Dustin Johnston (who 3 putted from 12 ft. 4 in. on the last hole, costing him the 2015 US Open) and Doug Sanders (who missed a 3 ft. putt on the last hole, losing him the 1970 Open Championship). These are in contrast to Mike Weir's and Jordan Speith's successes, both winning Major championships by remarkable putting. Furthermore, testing a skill's robustness under realistic sources of pressure/transfer is coherent with applied models of technical change (the Five-A Model; Carson & Collins, 2011), a crucial factor for coaches and sport psychologists (Carson & Collins, 2016b) working with golfers already experienced in using the BFA method but attempting to modify their putting to a TFA approach.

Reflecting an interaction of possible mechanisms, current understanding of the anxiety–performance relationship explains a breadth of cognitive, physiological and self-regulatory (Cheng, Hardy & Markland, 2009) but also motoric (Carson & Collins, 2016a) dimensions acting across perceptual, skill selection and execution phases of the performance (Nieuwenhuys & Oudejans, 2012). As such, we suggest that golfers require an optimum, although individually specific (e.g., Bortoli, Bertollo, Hanin & Robazza, 2012), blend of these dimensional functions across phases of performance and development. Further investigation of TFA with the inclusion of high-anxiety testing may assist in building our declarative understanding of, for example, how such factors interact, their relative importance, who should be using TFA and, crucially for coach decision making, why. In practical terms, monitoring of key process markers has the potential to improve the provision of quality feedback (Collins, Carson & Cruickshank, 2015) and subsequent training (including that of mental skills) to promote better competitive performance.

Varying green topography. A common demand on golfers within the task of putting is to, despite the closed environmental nature, correctly read the different slopes and pace of putting surfaces. In a study by Wilson and Pearcy (2009), visuomotor control was assessed for flat and breaking putts. Unsurprisingly, performance data indicated that golfers (six university golf team members, no reporting of their skill level) found severely sloped putts more difficult than either the moderate or flat putts. Slopes and undulations are utilised by golf course architects to increase the difficultly level of putting. Unpredictable and irregular topography requires the golfer to accurately perceive and determine the proposed path the ball will follow towards the hole. Golfers must calculate the degree of break, the speed of the green and the force required to project the ball the correct distance to the hole. Unfortunately only Bowen (1968) tested putts of different slope. Experimental testing of TFA on a variety of putting surfaces may therefore provide a better idea about its effectiveness when compared to BFA.

Investigating TFA: How it *Might* Work and be Assessed

Considering the nature of putting, it is most appropriate to present possible explanations that are grounded within motor control literature. Notably, and recognising the complexity of processes involved across multiple timescales (see Newell, Liu & Mayer-Kress, 2001), we limit possible explanations here to situations in which TFA is a learnt and well established (cf. Carson & Collins, 2016a) putting method. However, we explore multiple levels of explanation (Rose, 1997) within this diverse domain (e.g., Gallicchio, Cooke & Ring, 2017; Keogh & Hume, 2012; Vickers, 2016) presenting three possible (of possibly many) explanations for how TFA *might* work, offering visual, nonvisual/internal focus and physio-mechanical perspectives. Notably, these mechanisms may not operate in pure isolation, nor might this balance be equivalent across individuals. Considering the early stage nature of research into TFA however, we feel it is most beneficial to present the ideas as separate for optimal overall understanding.

Visual Explanation

Perhaps the most *intuitive* advantage for using TFA comes from benefits in visual system functioning while putting. Indeed, many studies have suggested that there is a relationship between golfers' eye gaze patterns and performance levels; the most common variable of interest being the quiet eye (QE), or final fixation (Vickers, 2016). For clarity, the QE is defined as the final fixation toward a specific location or object in the task space within 3° of visual angle for a minimum of 100 ms. Onset occurs prior to a critical movement in the task and the offset occurs when the gaze deviates off the object or location by more than 3° of visual angle for a minimum of 100 ms. According to several studies a longer demonstration of QE is indicative of expertise, especially for closed and self-paced skill aiming tasks (e.g., Mann, Williams, Ward & Janelle, 2007; Vickers, 2012).

Furthermore, Lee, Ishikura, Kegel, Gonzalez and Passmore (2008) suggest that a more difficult egocentric (versus the novice preferred allocentric) head–putter coordination pattern may have predominated due to enhanced information gained from the visual system. In short, this strategy supports an *attentional* explanation, utilising retinal feedback to extract superior information from the environment. Extrapolating this perspective, TFA may, therefore, provide pertinent environmental information to the golfer for longer durations and/or prevent visual distraction from the movement of the club head and/or hands during the execution. As such, eye tracking may prove to be a worthwhile avenue for investigation into TFA. However, and as highlighted by prominent researchers within the field (Reinhoff, Baker, Fischer, Strauss & Schorer, 2012; Wilson, Wood & Vine, 2016), despite what appears to be conclusive data, we are still unaware of exactly *why* the eye is quiet during such executions.

Nonvisual/Internal Focus Explanation

To address this conundrum it may be important to consider whether what an athlete focuses on *is* the same as what they are looking at or indeed, thinking about. Study into target shooting by Loze, Collins and Holmes (2001) distinguishes between states of attention (as described above) and *intention* (see Wertheim, 1981). In this case, *intention* refers to a consciously controlled, centrally-driven feedforward mechanism of retrieval that is not dependent on the input of retinal information. Preshot electroencephalographic (EEG) alpha power reactivity during expert air pistol shooting demonstrated marked differences over the time course of the execution, showing higher power during the state of intention versus attention (Loze, Collins & Shaw, 1999). This effect has been found to increase intra-individually before best shots in expert air pistol marksmen and elite archers (Landers, Han, Salazar, Petruzzello & Kubitz, 1994; Salazar et al., 1990; Shaw, 1996). In addition, such patterns of neural activity have been observed on an interindividual level between sporting experts and non-athletes (Collins, Powell & Davies, 1990; Cremades, 2002; Crews & Landers, 1993; Del Percio et al., 2007; Hatfield, Landers & Ray, 1984; Loze et al., 2001; Salazar et al., 1990). This is thought to be a sign of cortical inhibition during the period of stillness that occurs at the execution phase of a skilled motor act (Loze et al., 2001). Once the target is located and fixated on with an inevitably natural, but consistent, sway pattern, there is no longer a need to attend to the target; as it is not going to move (see Sheridan, 1991). Subsequently, a focus on controlling a smooth trigger pull, crucial for performance success (see also Bortoli et al., 2012), is initiated.

Notably, this explanation is in contrast to the constrained action hypothesis, which implies that athletes should be discouraged from focussing internally and instead advocates a universal benefit towards an external focus (Wulf, 2016). However, this argument and the studies used to derive it have recently been critiqued due to their lack of consideration toward motoric factors, such as the organisation, level and consistency of automaticity across movement components comprising the motor skill (cf. Carson & Collins, 2016a). From this contemporary perspective, a "positive self-focus" (Carson & Collins, 2016a, p. 10) toward the movement can serve to consciously activate the motor representation when thoughts relate to the entire movement (i.e., a holistic focus) *or* because an important, task-relevant component being focused on is highly-associated across others. Either way, these foci offer a beneficial action strategy to athletes for ensuring activation of the entire skill from long-term memory, especially when executing under novel or difficult conditions (cf. Christensen et al., 2016).

Accordingly, therefore, this nonvisual/internal focus activity may also be relevant for golfers when using the TFA method. A golfer might first *attend* to the target by fixating on the entry point of the hole (i.e., an external focus), then *intend* to initiate the putting action by focusing on an individually-optimal and familiar bodily thought (e.g., Maurer & Munzert, 2013). Furthermore, and as a consequence of avoiding vision of the ball and club head, this may reduce distraction and potentially intrusive thoughts (e.g., "what's the club doing?") to permit even greater focus on the movement action. Therefore, in this scenario the more revealing measure might also be to employ EEG.

Physio-Mechanical Explanation

Finally, the employment of TFA may promote mechanical advantages during the putting stroke execution through a change in postural setup. As an exemplar of such difference within basketball, consider the relative effectiveness of free throwing using the conventional overarm, single handed, technique versus underarm, two handed, technique. When implementing the latter there is a clear mechanical advantage in that the movement and control of both limbs are more balanced, or in-phase (Haken, Kelso & Bunz, 1985), thus predictably resulting in greater success (Venkadesan & Mahadevan, 2017). Unfortunately, however, putting literature is predominated by kinematic studies of the putter rather than in-depth (i.e., six degrees-of-freedom) analysis of the golfer to afford such insight (Delay, Nougier, Orliaguet & Coello, 1997; Karlsen, Smith & Nilsson, 2008). Might it be that tension in the neck and shoulder region when using TFA, in some way, makes the mechanics of the skeletal system different?

Based on findings from MacKenzie et al. (2011) showing a reduction in the variability of club head velocity at impact when using TFA, differential organisation of the skill by the central nervous system could be a possibility (Scholz & Schöner, 1999). Adding to this, and exemplifying a distinct interactive effect across explanations, reductions in club head variability may *also* reflect differential organisation of the movement as a consciously initiated adaptation of the representation by the golfer (Carson, Collins & Richards, 2014), or potentially as a result of the experimental conditions employed (Carson, Collins & Richards, 2016). Indeed, this postural change, and associated components to the process, may allow the golfer to better estimate the correct amount of force to apply at impact, thus effecting the stroke speed variability (Cockerill, 1978; MacKenzie et al., 2011; Williams, Singer & Frehlich, 2002). Presently, however, the precise underpinnings of how this may work remain outside the capability of this review. On the basis of these discussions, it follows that in-depth kinematic and EMG tracking to determine the processes involved during the different phases of the putting stroke, such as impulse application and swing mechanics, would be well suited to explore this explanation (Sim & Kim, 2010).

Considerations for Future Research

Addressing What Has Been Missed

Understanding what is going on. Human movement is the outcome of a plethora of biopsychosocial processes and it would be unsurprising to find similar interactions during TFA. This indicates, therefore, that future investigations into TFA must be able to account for such complexity but, for now, we simply do not know how or why TFA works, nor do we know what components or processes may or may not be associated with this phenomenon. As a case in point, alpha rhythms have not been investigated whilst putting using the TFA method. As such, there is a rationale for employing similar methods used in previous closed skills sport research to help understand how TFA might work (Gallicchio et al., 2017; Loze et al., 2001). Moreover, it is not what these processes *will* show us but what *could* be shown.

Moving forward, markers should be employed in research that reveals greater insight into how TFA might work. In addition, despite increasing literature surrounding the importance of vision, nonvision/internal focus and physio-mechanical control, there is no research regarding the efficiency and impact of TFA on putting performance when combining these control elements. Therefore, it is important that future research seeks to understand these mechanisms within representative environments and subsequently exploits this information within applied coaching practice. It would follow that identification and formative assessment of TFA as an appropriate aiming strategy following training interventions may reveal findings that can be applied in practice and utilised with confidence in a naturalistic, competitive and pressured environment. Furthermore, future research should consider the limitations surrounding ocular dominance and visual acuity prior to testing. As such, the evidence-base available is far from complete in explaining how TFA works.

The authors expect that any major change to a golfer's posture—eyes, head and neck position—during the stroke could, or should, cause degradation in performance. Therefore, a starting point for future studies would be to assess and interpret the putting skills of elite performers who have always putted using the BFA method and establish if the TFA method disrupts their performance. Furthermore, examining and investigating the golfer's physical characteristics including; height, vision acuity, postural and putting setup to determine the optimal position of the neck, head and eyes when engaging in the TFA method should prove productive. This information may then be used to assess lower skilled performers and for TFA training. Therefore, previous research would be further enhanced if future trials included elite amateur and professional golfers who have honed their putting skills.

Summary and Conclusion

In this paper we suggest that current research into TFA is unfortunately characterised by several important inconsistencies and omissions. Consequently, this limits golf coaches' ability to know whether the method *is* effective, how it works and, therefore, who should use it, when and how it should be coached. More generally, we highlighted the need for research to be conducted as a linked chain whereby methodological revisions are data driven.

Accordingly, vision, nonvision/internal focus and physio-mechanical hypotheses were suggested that may provide impetus for an enhanced level of understanding. In conclusion, much work is needed toward TFA in the future and this should be systematic in its approach. At present, while anecdotal evidence of TFA's use by professional players and enthusiastic amateurs is interesting, that is all we really can say. Therefore, with great anticipation we await to gain a better understanding through future research studies, which may have a substantial impact within the applied setting.

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Table 1. *Overview of Research to date Investigating Target Focused Aiming in Golf.*

Study	Purpose of Study	Theoretical Perspective Adopted	Participant Characteristics and Number (*N*)	Context Tested Under	Type of Manipulation(s)	Conclusions	Citing Research
Bowen (1968)	To determine if beginner golfers made characteristic errors over various putting terrains and to discover if looking at the ball vs. at the hole while putting would increase accuracy.	No mechanistic explanation provided; however, tentatively cognitive orientation towards the results.	Beginner male college students (*N* = 100). Eight were left-handed and 92 right-handed. A standardised putter was used.	Outdoor synthetic level and angled carpet surface (hair and jute).	BFA vs. TFA. 300 putts – 25 from 15ft, 25ft and 35ft on a level surface and repeated on an uphill-sidehill surface, a downhill-sidehill surface and an undulating surface.	No significant difference in performance between BFA and TFA groups for any condition (slope or distance). Success in putting distance and direction is not related to gaze direction. Emphasised instruction on distance control and the influence of slope is required.	None
Cockerill (1978)	To determine how effort control in putting might be facilitated among low-	Cognitive but with minimal mechanistic discussion.	Right-handed, male low-handicap golfers (*n* = 20; < 6 handicap; aged 22–42 years) and non-golfers (*n* =	Laboratory, 0.1m high synthetic putting mat with standard hole cut.	BFA vs. TFA. Putting distances of 1m and 2m. Vision restricted by a triangular blinker attached to	Putting distance was a significant source of performance variation. Non-golfers mainly suffered from	Bowen (1968)

	handicap golfers and non-golfers.		20, aged 20–38 years). A standardised centre shaft putter and Dunlop 65 ball were used.		the left side of the head for BFA and right side for TFA. Each participant executed 25 putts from each distance.	directional errors to the right of the hole using TFA. For TFA to be effective in experienced golfers, it was suggested that the golfer would benefit from early exposure to using the TFA method.	
Aksamit & Husak (1983)	To determine the influence of two forms of visual control and one kinesthetic technique on accuracy of putting	Cognitive	Right-handed, female, non-golfer college students (*N* = 27). Standardised putter and ball used.	Natural putting green (30.5ft × 40.5ft).	BFA vs. TFA vs. no vision (using blackened goggles). Participants randomly assigned into each of three groups. 5 putts from 5ft, 10ft and 15ft per group.	No significant difference across the three conditions. As distance decreased the groups mean errors decreased. No vision during early skill acquisition may be beneficial by forcing attention toward important movements and preventing information-processing overload from	Bowen (1968)

						irrelevant environmental information.	
Wannebo & Reeve (1984)	To examine the role of sensory feedback and skill level in golf putting performance.	No theoretical perspective adopted.	Highly skilled, male golf students (minimum 3 years' experience; *n* = 11) and low-skilled golfers (< 6 months' experience; *n* = 11). Participants used their own putters or the one supplied. 5 range balls were used (non-conforming for competitive play).	Natural putting green (~40ft × 35ft).	BFA vs. no visual cues (blindfolded) vs. irrelevant visual cues. 5 straight putts from 5ft and 15ft in each condition. Offset marker (the irrelevant visual cue) was placed 58in. from the hole and marked with white tape as an 'X'.	BFA was significantly more accurate compared with the other two conditions. There was no significant difference between no visual and irrelevant visual cues. Relevant visual cues are important for accurate putting.	Aksamit & Husak (1983); Cockerill, (1978)
Gott & McGown (1988)	To determine the effects of two putting stances (conventional vs. side-saddle) and two points of aim (ball vs.	Cognitive but with minimal mechanistic explanation.	12 male and 4 female right-handed students enrolled in beginner (inexperienced) golf class.	Laboratory, synthetic level putting surface (10ft × 25ft) with hole.	Conventional stance vs. side-saddle using BFA and TFA combinations (i.e., 4 manipulations) from 5ft and 15ft.	No significant differences at any distance between point of aim or stance.	Bowen (1968); Cockerill (1978)

	hole) on putting accuracy.		Participants were randomly divided into four gender-balanced groups.		Practice: 60 putts from each distance 1 day per week on weeks 1, 3, 5 and 7. Testing: Same as practice but in weeks 2, 4, 6 and 8. Incentive rewards each week for most number of putts holed.		
Alpenfels, Christina & Heath (2008)	The intent of this book "Instinct Putting" (IP) is to impart a clear understanding of IP and act as a guide to adopting IP for your own game through a program of practice drills and exercises	Cognitive	Experienced adult male and female amateur golfers (handicap 8–36; *n* = 40). Two groups (BFA and TFA) of 20 were balanced for handicap and gender.	Natural putting green.	BFA vs. TFA Putts from 20ft–40ft (long) and 3ft–8ft (short). Pre and post-tests from 3ft–43ft. Each group practiced 45 putts to nine different holes ranging in	TFA was significantly better for distance control at long distances. TFA is an effective practice drill for BFA users. TFA is easy to learn; however, performance may be expected to decline initially	None

					distance from 5ft–45ft.	before improvements are evidenced.	
MacKenzie, Foley & Adamczyk (2011)	To evaluate BFA vs. TFA, following a series of practice sessions.	Cognitive	Thirty-one male golfers (handicap 18.7 ± 10.4; M_{age} = 22.3 years ± 4.1). 11 left- and 20 right-handed. All putts were executed with a standardised Nike Unitized Retro putter. Balls (Callaway Tour*i*) were marked with a straight line for aiming purposes. Participants were provided with a correctly orientated aim line to improve internal validity and affect	Laboratory, synthetic putting surface 7m × 5m. Green speed stimp (~11.5ft).	BFA vs. TFA. Pre-test–4 week practice (BFA or TFA)–post-test (using both TFA and BFA at 1.22m and 4m). Straight putts.	Post-test results showed TFA practice group significantly reduced variability in putter speed. TFA practice did not affect the quality of impact of putter–ball contact. Four weeks of practice using TFA method resulted in improvements in putter speed consistency when tested using TFA but this finding also remained when returning back to BFA.	Aksamit & Husak (1983); Bowen (1968); Cockerill, (1978); Gott & McGown (1988); Wannebo & Reeve (1984)

			generalizability of results. Participants were divided into two matched groups based on their pre-test putting performance.				
Gonzalez, Kegel, Ishikura & Lee (2012)	To examine effects of vision on head-putter coupling	Cognitive	Twelve right-handed participants (3 male, 9 female) with less than 3 years of golf experience. All used Titleist NXT golf balls and a Ping Anser Putter.	Laboratory synthetic carpet (632cm × 183cm) with a speed reading of 13 on the stimp metre. Putts were to two golf hole sized targets located at distances of 3m and 5m.	Each participant executed 3m and 5m straight putts under four conditions (Full Vision, No Vision, BFA-Restricted and TFA). Opaque sheet used to remove vision of the ball and immediate surrounding area. The BFA-Restricted condition had a modified opaque screen to constrain visual information which included the	Visual strategies play a role in the coordination of head and putter motions and outcome of putts. Full Vision resulted in considerable head movement throughout the putt. No Vision condition had no effect on reducing head movement. TFA reduced the head movement	Alpenfels, Christina, & Heath (2008)

			entire ball and putter head as it struck the ball by the golfer. 10 practice putts permitted in each condition. The eight experimental conditions were run in four blocks of sixteen putts, four putts in each condition (two putts per target distance).	and had the largest effect on head–putter coordination pattern but lead to a decrease in performance outcome. BFA-Restricted like TFA was successful by decoupling the degrading effects of an isodirectional coordination pattern BFA-Restricted being the optimal condition for this experiment.