# LEARNING GOLF DRIVE: NATURAL SWING PATH TENDENCY TO SLICE, FADE OR PULL

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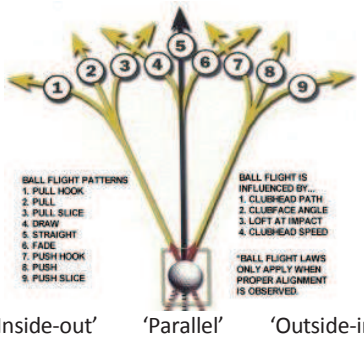
The purpose of this study was to identify if there is a natural tendency to deviate from a parallel-to-target line at impact, while learning the drive swing. During coaching, on a reduced-size driving range, the participants (n=10) only received augmented feedback related to *knowledge of performance* by combining Leadbetter Interactive and SmartSwing analysis software. To capture motion data, augmented coaching equipment included two video cameras and a SmartSwing™ club (3D sampling at 1000 Hz). To overcome SmartSwing's inability to export swing datasets directly into a spreadsheet file and to eliminate human error, the swing reports (s=328) were exported using independently developed software. Findings related to the natural tendency to *slice, fade* or *pull* can aid golf coaching activities, club-fitting and golf technology.

**KEY WORDS:** knowledge of performance, augmented coaching technology.

**INTRODUCTION:** The saying in golf coaching 'the ball flight doesn't lie' relates to *knowledge of results* feedback, which is associated with the outcome of the movement. The other type of feedback, *knowledge of performance* is associated with the swing as a movement process. While club-fitting to optimise the outcome of movements is a well established practice, there is little scientific evidence on swing tendencies that could also help coaching and the learning of golf, or club design selection. The aim of this study is to find out if, during the learning of a golf drive swing, a sample of golfers (novices, without a handicap) has a natural swing path tendency if knowledge of results feedback is suppressed. Information related to natural swing path tendencies for golfer profile(s) can advance coaching, learning, club-fitting, as well as help inform club selection and alternative club designs.

**METHODS:** The coaching programme, analysis and feedback elements were obtained by combining augmented golf coaching software ("Leadbetter Interactive," 2005) and embedded technology ("SmartSwing," 2005). In agreement with the general application and the power of knowledge of performance feedback over knowledge of results (Knudson and Morrison, 2002a), the participants in this study received only knowledge of performance feedback, while the ball flight information was suppressed. The analysis and feedback from the SmartSwing™ system is based on quantitative 3D swing data processing (Figure 2), including computed angular deviations from a 'Parallel' swing path at ball impact (Figure 1).




Not actual ball trajectories. *Dave Tutelman's conceptual model unifying the nine ball flights (retrieved on 2 Jan. 2014, from http://www.tutelman.com/golf/ballflight/ballflight.php) was reproduced with the author's permission.*

'Inside-out' hook, draw, or push

'Parallel' straight, draw or fade

'Outside-in' slice, fade, or pull

*Swing paths categories*

**Figure 1: Mapping of the nine ball flight categories into three swing paths as categorised by the SmartSwing™ system (ImprovingYourSwing.pdf).**

The rationalle depicted in Figure 1 is also supported by J. K. Suttie (2006, pp.12-20). The swing data were captured via a SmartSwing 6 DOF sensor in the club (Nass, 2005) sampling the club position in 3D space at 1000 Hz. Coaching included a set of golf lessons with required camera setup ("Leadbetter Interactive," 2005). This augmented coaching setup incorporates semi-automated qualitative analysis from captured video recordings (Bačić, 2006), which is also adhering to *systematic observational strategy* and recording rigour from existing literature (Knudson and Morrison, 2002b; Alderson and Elliott, 2006).

**Swing Dataset Export:** The software (Figure 2) was developed (in Borland's Delphi ver. 6) to export multiple SmartSwing reports from PDF file format into text and then into a CSV spreadsheet file with automated removal of incomplete samples. Data from PDF reports were exported via the clipboard object library, utilising ActiveX and OLE technologies. The PDF data export was designed to adhere to the manufacturer's end-user licence agreement.

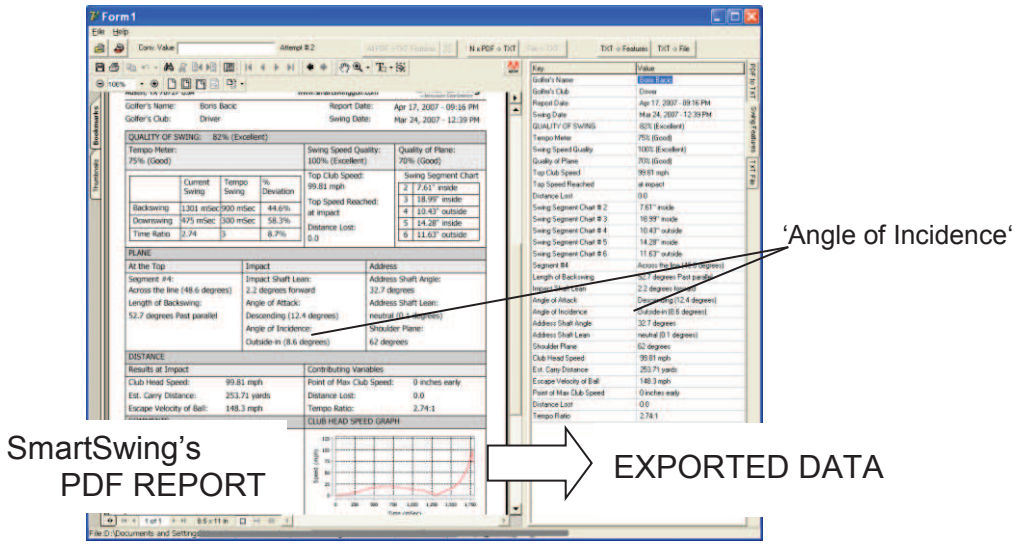



**Figure 2: Data export utility developed for this study.**

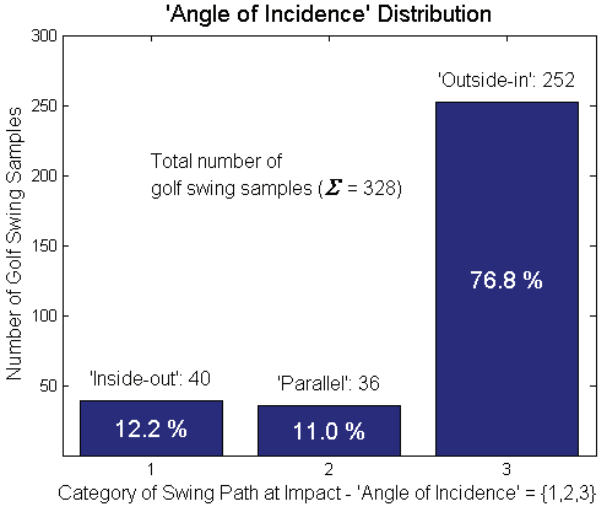
**Data Collection:** Prior to this study the related ethics approval was obtained from the AUT Ethics Committee (AUTEC No. 06/105). The participants (n=10) in this study included five females and five males, of diverse age (17-55+ years) and height (157-180 cm). The participants followed learning programme (Table 1), with analysis and feedback complying with Leadbetter Interactive and related studies (Hume *et al.*, 2005; Keogh and Hume, 2012; Langdown *et al.*, 2012).

**Table 1**
**Golf Lessons Plan with Suppressed Knowledge of Results (Bačić, 2013)**

| Lesson | Introduced concept and focus | Remarks |
|---|---|---|
| 1. | Introduction lesson:<br>Grip, ball addressing and stance basics information.<br>Basic swing information. | Information pre-session included general and local driving range routine information, biometrics measurement for club initialisation<br>Making sense of basic technique. |
| 2. | Stance focus: Posture and ball addressing.<br>Hand and arms 'softness feel'<br>Back swing (right knee and coil resistance) information. | Upper body and knees corrections, technique corrections.<br>Importance of activating large muscles (consistency) over small muscles (variability). |
| 3. | Basic swing motion and dynamic posture stability:<br>Focus on 'steady knees', hips, trunk and head. | Introduced wrist release, length of the swing, head, upper body, and knees corrections.<br>Achieving a 'comfort zone'. |
| 4. | Ball impact and swing features. | Introduced concept of swing parameters related to ball flight. |

**Experimental Setup:** All participants had to: (1) warm-up (using shorter to longer irons followed by 5-, 3-wood and two other driver clubs) before the SmartSwing driver for data recording; and (2) cool-down and stretch after the recording session. Swing analysis and feedback were produced by combining the SmartSwing™ system and Leadbetter Interactive two-camera setup (front and rear sagittal views) with a subject positioned in the middle of the four bays with 18 m to the back-end fence on a reduced-size driving range.

**RESULTS:** For the represented sample of the golf learners' population, the unbalanced distribution of ball impact categories (Figure 3) indicates a natural swing path ('Angle of Incidence') tendency for an 'Outside-in' resulting in *slice, fade* or *pull* (Figure 1).




SmartSwing™ categories of swing path at impact *(computed from data)*:
1='Inside-out' • • 2º •
2='Parallel'
3='Outside-in' • 2.1º

Analysis, calculations and extended figure visualisation for readers' convenience were programmed in MATLAB® ver 7.1.

**Figure 3: Unbalanced distribution of swing paths tendency.**

**DISCUSSION:** Regarding the 'Outside-in' tendency: (1) Beginners should still focus on improving their basic swing technique and, as they progress in their skills, they should gradually learn typical interventions for common errors linked to 'Outside-in' swing path at impact. The next learning challenge is then to achive deliberate control of the ball flight trajectories to adapt to challenges from diverse golf courses; (2) Consistent golfers who struggle to change their 'Outside-in' swing technique should consider swing personalisation with their coach's assistance in diagnosing, prioritising various causes of errors and in attempting various interventions before club-fitting; and (3) Sport shops may offer drivers with a slightly shorter shaft and a closed face for golfers with 'Outside-in' swing path tendencies, similar to Figure 3. In the author's view, distance, consistency and ball flight control should come as a consequence of good swing technique that is developed early, with the help of a coach. Reduced-size driving ranges may help beginners to focus more on their swing technique rather than on the ball flight distance.

In general, coaching technology provides means to combine augmented and self-coaching with traditional coaching. For example, the participants would exchange emails discussing their individual learning experience with the author/coach between face-to-face sessions and receive analysis and feedback reports including the analysis artefacts produced using the augmented coaching software. Accurate 3D and video replays with semi-automated analysis provide athletes with an elevated degree of confidence, compared to verbal feedback only. Semi-automated video analysis in the Leadbetter Interactive was achived when a user would compare captured videos and match them with similar swing actions provided by the software, which would then generate a set of recommended interventions (video drills). Augmented coaching technologies also facilitate communication and assessment consistency, reliability and rigour, even with less experienced coaches. In augmented coaching, the notion of feedback, with a minimal degree of obtrusion and fast automated analysis, could be achieved by combining video with 2D and 3D motion data from embedded electronics/sensors, wareable or other sports technology (e.g. www.trackmangolf.com,

accessed 10 Jan. 2014) where, for example, motion data can be captured at a high sampling frequency and resolution beyond human cognitive ability. The incresing presence of embedded/smart sensors in areas of augmented coaching represents the opportunites to obtain data that will enable new scientific discoveries.

**CONCLUSION:** The study revealed the natural swing path tendency to *slice, fade* or *pull* for golf learners when learning the drive swing with suppressed knowledge of results information. The findings associated with the swing path tendency, the discussed real-life utilisation of augmented coaching technology and independent data export software, can all help in coaching practice, club-fitting, club selection, sport science and advancements of augmented coaching technology. To compensate for the reported swing path tendency, club manufacturers may consider offering design alternatives and customisations to help golfers to improve their individual game before gaining fine-control of the ball trajectories. Advanced golfers and coaches may try mixing old and new drivers in their practice to extend their 'feel' and preferences for diverse clubs. For this and future studies, to automatically obtain swing data and to eliminate the potential for human data-entry error, the software was developed to independently extend the utility of the SmartSwing™ system – achieving that all of the SmartSwing's reports (in PDF format) were processed for errors and exported into a spreadsheet file for the quantitative analysis of swing data. The achieved data export via the clipboard object library is a low-cost solution that can be adapted to export data from other motion capture systems. Sport technology developers may consider providing data export functionalities and sharing of their *software development kit* (SDK) to advance research development and collaboration, improve club-fitting personalisation and to attract a broader community of user profiles. The assets from augmented coaching systems, analysis and media post-production allow coaches to choose extra elements to be combined in the feedback, compared to traditional coaching. Future work on the achieved relatively large golf swing dataset has the potential to provide further golfing insights and to promote cross-discipline research.

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