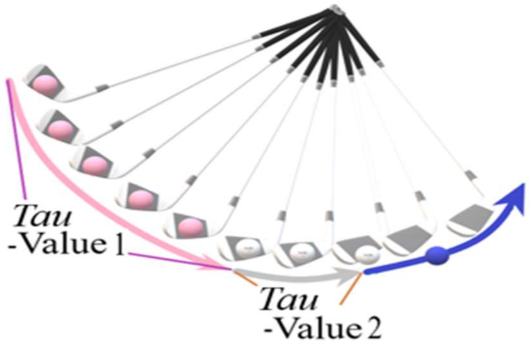
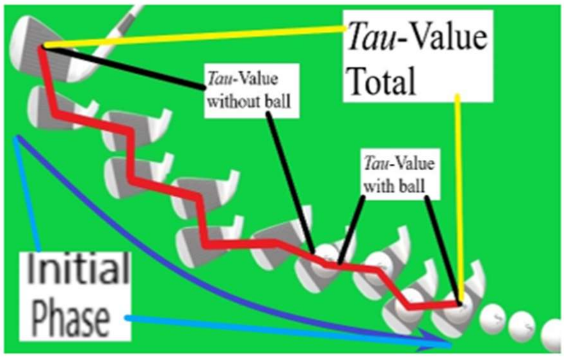
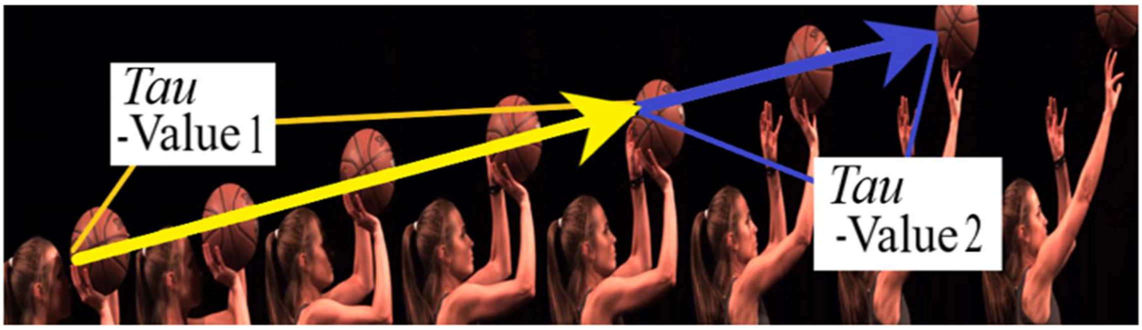
Golf - Perceptual Adaptation Reveals All Details within the Functional and Behavioral Perception Processes: A Comparison between Golf and Basketball

The complete explanation of *The Quiet Eye (TQE)* within golf and basketball







Caught In A Line
The explanatory model of all motoric movement actions

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October 2024 ©

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Abstract

This article presents an explanatory model that is capable to universally clarify all functional perception processes involved in any conceivable action, such as a golf swing or a basketball shot. The model outlines how three autonomous foci simultaneously contribute to the successful execution of these actions. In both golf and basketball, one focus is directed at the movement of the external object, i.c., the hole or the basket, while the other two foci are directed at the movement of the ball within the egocentric action. The model emphasizes that the successful execution of an action begins with a visual tactical phase, where a perceptual image of the entire latent outgoing ball trajectory shape must be reduced to an initial phase, because it is an established fact that the ball can only be manipulated during the period of haptic contact.

A significant contribution of this article is the concept of perceptual adaptation, which bridges the apparent differences between actions in different sports. At first glance, golf and basketball seem entirely different, but an applied perceptual adaptation clearly demonstrates that all motor actions follow the same universal perception processes. It is shown that it does not matter whether, in basketball, the ball must first be moved to point P where the final push-off takes place, or whether a golf club solitarily must be moved to a golf ball already positioned at that point P. The push-off c.q. the release phase from that point P is the crux of the action, and it is identical in both cases.

The explanatory model of all motoric movement actions offers, with the concept of the perceptual adaptation, not only scientific and theoretical depth but also provides practical insights for sports coaches to optimize athletes' performance through explicit task descriptions and new methodological/didactic insights.

Introduction

In 2016, a theoretical model was developed that is capable to clarify all functional perception processes involved in any goal-directed motor action. This model provides a universal explanation, showing that the execution of any conceivable action always depends on the simultaneous perception of

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three autonomous foci. One of these foci remains directed at the (movement of the) environment object, which universally represents a catch action, such as the hole in golf or the basket in basketball. The other two foci are concerned with the perception of the movement of the ball within the egocentric action, which can universally be described as a throwing action.

The three foci are extensively described for both golf[1] and basketball[2] and reveal an identical structure. They demonstrate the following:

1. **Tactical phase and initial phase**: In the tactical sport action (TSA), which precedes the factual sport action (FSA), a perceptual image of the complete potential outgoing ball trajectory shape must first be formed through visual perception. This image is then reduced to a perception of the initial phase of this trajectory, due to the fact that a successful end of an action trajectory shape can only occur during the phase where there is haptic contact with the ball.
2. **Execution of the initial phase**: During the actual execution (FSA), only the initial phase of the outgoing ball trajectory shape is perceived and executed. This concerns the autonomous perception of an external action trajectory shape, which can solely be achieved through autonomous internal (proprioceptive) perception processes. These two autonomous foci—internal and external—operate independently of each other, resulting in a challenge: the ball will, due to the autonomy of these two foci, deviate at any point P from the latent perceptual image of the initial phase within the external focus.
3. **Corrective perception processes and gaze**: Cortical processes continuously mediate these deviations, ensuring that the tactically determined perceptual image of the initial phase is constantly updated. This mechanism forms the basis of what is known as "gaze." *Gaze* is thus not a static focus but the result of an ongoing process of refinement and adjustment by the cortical streams that guide the movement of the ball during the initial phase of its trajectory, both in golf and basketball.

Although these findings are identical in golf and basketball, there appear to be significant differences between the two actions. This is mainly because the basketball is continuously held in the hand, whereas in golf, the golf club must move independently toward the ball. These differences can make it challenging to explain the perception processes consistently.

The theoretical model presented in this article, however, shows that these apparent incongruities can be resolved through the phenomenon of **perceptual adaptation**. For example, in a golf swing, a perceptual image can be formed in which the golf ball is continuously "held" on the clubface during the main phase of the swing, similar to how the basketball is constantly held by the hand during a shot. This mechanism of perceptual adaptation bridges the differences between the two sports actions and demonstrates that they rely on precisely identical perception processes.

Perceptual Adaptation

a. **Perceptual Adaptation in a Golf Swing**

Within the explanatory model of the motoric movement action, perceptual adaptation in golf refers to the process by which the player forms a mental image in which the golf ball is already positioned on

[1] https://www.explanatorymodel.nl/sports-actions-1/golf
[2] https://www.explanatorymodel.nl/sports-actions-1/basketball, https://www.researchgate.net/publication/382250091_The_complete_clarification_of_all_functional_perception_processes_within_the_free_throw_in_basketball.

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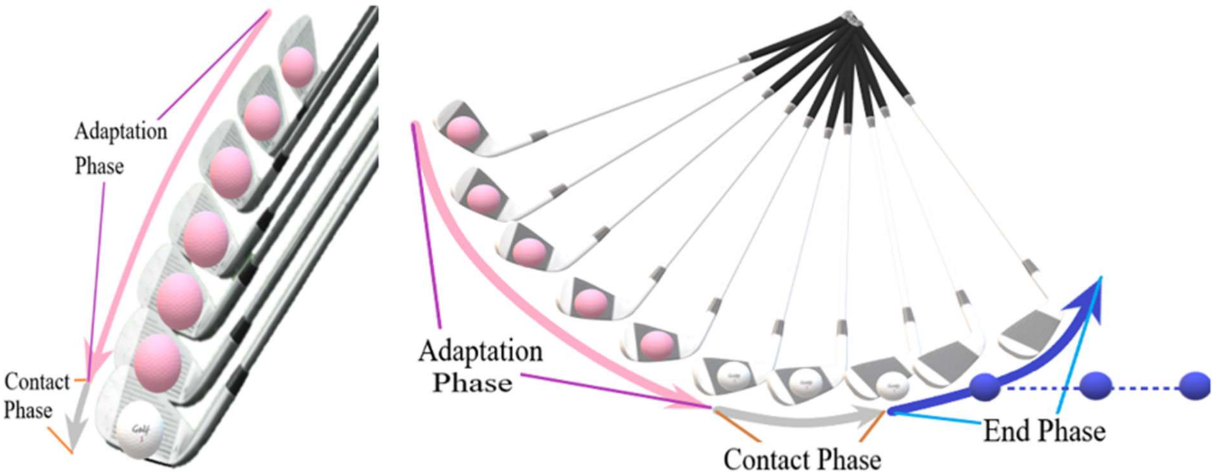
the clubface from the beginning of the main phase of the swing. This mentally constructed image ensures that the ball is continually perceived as being in a fixed position on the clubhead, precisely where the real ball will eventually be struck. This mental representation serves as a stable reference point, making the transition from the imagined ball to the actual ball seamless, with no significant discrepancy affecting the execution of the swing.



Images: Perceptual adaptation in golf involves the mental image of the golf ball being present on the clubface throughout the main phase of the swing. The pink balls represent the imagined positions of the ball on the clubface, corresponding to the exact point where the ball will be struck. When this mental image is transferred to the actual ball (white), the imagined and real ball positions merge. This ensures that the ball is hit precisely as planned within the tactical sport action (TSA). The white balls represent the touching phase, from the first to the last haptic contact between the clubhead and the ball. The blue balls indicate the phase where there is no longer contact, corresponding to the beginning of the end phase of the swing.

Perceptual adaptation in golf now clearly illustrates where the functional perception processes during the main phase of the swing are aimed at. They can be divided into two distinct yet interconnected parts. In the first part, two tasks must be accomplished: a. **kinetic energy** must be generated, and b. a **line segment shape** must be formed, to enable the upcoming construction of the initial phase during the contact with the ball. In the second part, with the help of these two elements—kinetic energy and the trajectory—the golf ball must be propelled from the clubface along the correct action trajectory shape of the initial phase. Which will ensure that the ball independently reaches the hole.

The division in functional perception processes highlights a crucial transition point between the first and the second part within the main phase of every golf swing, which the cognitive and sensory processes target. Unlike sports such as basketball, where the ball is physically held continuously, in golf, there is no continuous contact with the ball. This makes it possible to clearly define that transition point: the first haptic perception of contact between the clubface and the ball. This perception can be both visual and proprioceptive, with the approach of the *tau*-value to zero in the first part of the main phase playing a key role.

This transition point separates the two parts of a golf swing: while the first part of the main phase functions independently of the second part, it is necessary for optimizing the impact process. It ensures that the conditions are created for the formation of the initial phase, from which the entire ball trajectory will implicitly have to emerge. So structuring the perception processes in this way is essential for the precise execution and success of the golf swing.

b. <u>Perceptual Adaptation in a Golf Swing Compared to a Basketball Shot</u>

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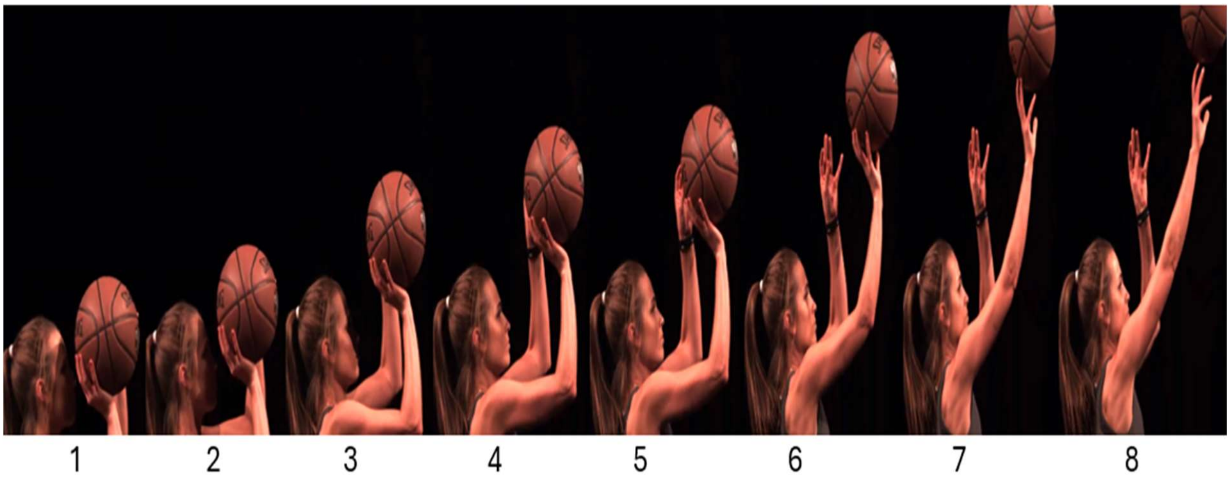
By applying perceptual adaptation to a golf swing, we gain better insight into the fine details of the functional perception processes. This becomes evident when we compare golf to sports where the ball is constantly held, such as basketball. The apparent differences then completely disappear, making the underlying perception processes universally visible.



Images: Even within the main phase of a basketball shot, the two consecutive parts are clearly distinguishable. The first part of the main phase (images 1-5) consists of raising the basketball to a certain transition point, involving *only arm action* (!). In the second part of the main phase, which involves pushing or releasing the basketball (images 5-7) from the body, the arm action continues, but hand action becomes clearly visible. Once the hand loses contact with the ball (images 8+), the main phase ends, and the sports action transitions to the final phase.

By allowing perceptual adaptation within a golf swing, it now becomes possible to fully analyze the functional perception processes in a basketball shot as well. Although the main phase is practically experienced as a single, continuous action, it can now be divided into two clearly distinguishable parts. In the first part, just like in a golf swing, the basketball is moved to a specific (transition) point, during which both a. **kinetic energy** and b. **an action trajectory shape** are generated to enable the construction of the upcoming initial phase of the departing outgoing ball trajectory shape.
However, the transition point to the second part of the main phase in a basketball shot can less clearly be defined. This point must be recognized when the arm action in the first part is supplemented by hand and/or finger action within the second part. This means that we must be able to perceive a *tau*-value approaching zero (primarily based on proprioceptive perception) at the moment of transition. This allows the body to initiate the additional hand and/or finger movements required for the next phase of the action.

Two Autonomous *Tau*-Values in the Main Phase of a Golf Swing

The main phase of both a golf swing and a basketball shot consists of two closely related parts. In the first part, two essential elements are generated: 1. **Kinetic energy**, and 2. The **shape of the action trajectory**. These elements are crucial to ensure that in the second part—where the actual initial phase of the ball's trajectory is formed—the movement aligns with the tactically formed latent perceptual image within the tactical sports action (TSA).
While this close relationship plays a central role in the practical execution of the action, the main phase, in terms of *tau*-values, can be divided into two autonomous phenomena. These autonomous *tau*-values form the foundation for distinguishing the functional perception processes in each part of the main phase, where the transition from kinetic energy and the shape of the action trajectory to the initial outgoing ball trajectory shape is carefully controlled.

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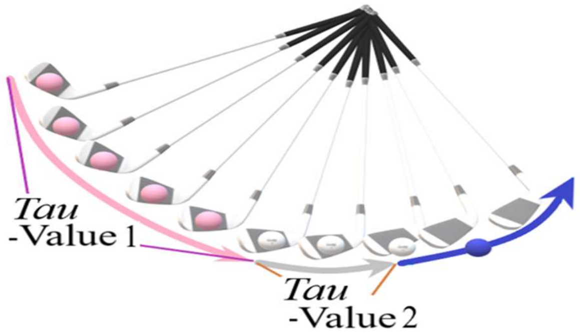
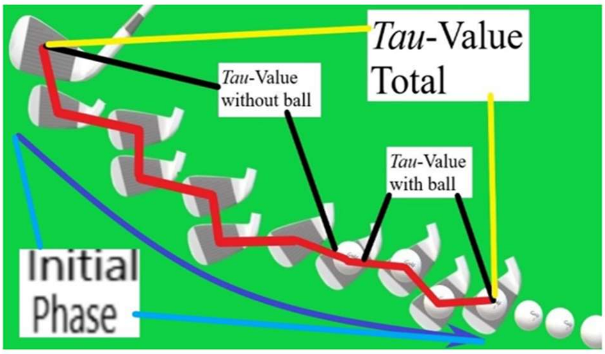
a. **The Two Autonomous *Tau*-Values in the Main Phase of a Golf Swing**

In a golf swing, two autonomous *tau*-values can be identified during the main phase. The transition between these *tau*-values is crucial for a controlled and precise golf swing, where visual and proprioceptive perceptions are optimally integrated.





Images: The first autonomous *tau*-value compels the perceptual adaptation of an imaginary ball on the clubhead towards the actual location of the ball. As the imaginary ball almost merges with the real ball—when the *tau*-value approaches zero—the push-off action will begin. This marks the start of the actual initial phase and the beginning of the second *tau*-value, which must be autonomously perceived. The clubhead action must have a fixed relationship with the perception that this *tau*-value is nearing zero, at which point it transitions to the final phase.

The first autonomous *tau*-value begins simultaneously with the start of the main phase, when the player moves the golf club toward the ball. During this phase, kinetic energy and the action trajectory shape are generated as the player fine-tunes the timing, speed, and direction of the swing. As the club gets closer to the ball, the first *tau*-value approaches zero. At this point, the imaginary ball and the real ball must fully merge, indicating that precise haptic contact is crucial at this stage.
The second autonomous *tau*-value begins at the first contact between the clubhead and the actual ball. At this point, the focus shifts from the *preparation* (!) of the initial phase of the outgoing ball trajectory shape to the actual execution of that phase. The golf ball is pushed along the previously formed action trajectory shape, while proprioceptive feedback helps to guide the ball with the correct direction and speed toward the hole. The push-off within this phase has a structured form c.q. a set length, and thus the second autonomous *tau*-value also has a cognitively determined end.

b. The Two Autonomous *Tau*-Values in the Main Phase of a Basketball Shot

In a basketball shot, two autonomous *tau*-values can be distinguished during the main phase. The transition between these *tau*-values is essential for a controlled and precise shot, where visual and proprioceptive perceptions are optimally integrated.

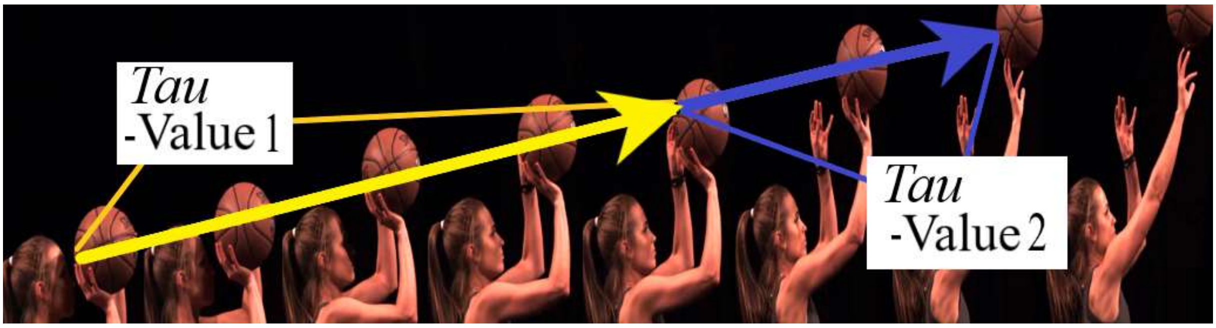


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Image: The first autonomous *tau*-value relates to the movement of the basketball towards the transition point, which solely involves arm action. When perception indicates that this point is almost reached—when the *tau*-value is nearing zero—the push-off/release action begins. This marks the start of the perception of the final part of the initial phase and the beginning of the second *tau*-value, which must be perceived autonomously. The hand action during this part must be closely aligned with the perception that the latter *tau*-value is approaching zero, at which point the motoric action shifts to the end phase.

The first autonomous *tau*-value begins simultaneously with the start of the main phase, when the player starts to move the basketball to the basket. During this phase, kinetic energy and the action trajectory shape are generated as the player fine-tunes the timing, speed, and direction of the throw. As the basketball gets closer to the transition point, the first *tau*-value approaches zero, and hand action must be added to the arm action.
The second autonomous *tau*-value begins at the first appearance of hand action. At this point, the focus shifts from the *preparation* (!) of the initial phase of the outgoing ball trajectory shape to the actual execution of that phase. The basketball is pushed along the previously formed action trajectory shape, while proprioceptive feedback helps to guide the ball with the correct direction and speed toward the basket. The push-off within this phase has a structured form c.q. a set length, and thus the second autonomous *tau*-value also has a cognitively determined end.

Conclusion

The comparison of the golf swing and basketball shot demonstrates that the apparent differences between these actions can be bridged through the concept of perceptual adaptation. Both sports actions require a close interplay between 1. kinetic energy and 2. the shape of the action trajectory during the main phase, where the final execution depends on precise timing and the perception of the present *tau*-values. These autonomous *tau*-values are crucial for distinguishing the functional perceptual processes in both phases of the sports action.
Due to the model of perceptual adaptation it is revealed that, although the physical interaction with the ball differs (direct hand contact in basketball versus indirect contact via the clubhead in golf), the underlying perceptual processes are universal. In basketball, the player brings the ball by hand to the precise point P where the initial phase of the outgoing ball trajectory shape begins, while in golf, the player moves the club towards the golf ball, which is already positioned at that precise point P of that initial phase. The mental representation of the ball, as in the case of the golf swing, ensures that the functional perceptual processes can extend to sports actions where the ball is continuously held, as in a basketball shot.
This explanatory model not only provides theoretical insights in movement sciences but also offers practical tools for sports coaches. By applying these insights, coaches can enhance athletes' performance through explicit task instructions and new methodological approaches, focusing on optimizing timing and execution at the crucial transition points of each sports action.

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