

# **Volleyball and Four-Dimensional Visual/Cognitive/Motor Symmetry: A Model for Performance Enhancement**

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## **ABSTRACT**

The volleyball athlete, as a dynamic visual/cognitive/motor operating system (VCM), is capable of performing in several operating modes simultaneously. The operating mode of the athlete in a normal performance state is a *serial* VCM operating mode, while the peak performance state (also known as ‘flow’ or in ‘the zone’) of that same athlete is a *parallel* VCM operating mode.

A serial operating mode engages the operating system in an Input/Processing/Output (IPO) interface that is four-dimensionally asymmetrical (4DA) relative to the elements of the Contact Sequence (CSQ) environment, and is the underlying cause of the athlete’s normal performance state. Conversely, a parallel operating mode engages the operating system in an IPO interface that is four-dimensionally symmetrical (4DS) relative to the elements of the CSQ environment, and is the underlying cause of the athlete’s peak performance state.

By reproducing this underlying 4DS interface, the athlete simultaneously reproduces not only the higher-level peak performance of the operating system functioning in its most efficient and accurate mode (parallel), but also the psychological, emotional, and spiritual behaviors known as the “flow components.”

Human performance can be viewed from this model as a fundamental cause/effect relationship between the operating mode of the system and its resultant performance state:

Cause: Serial Operating Mode (4D VCM Asymmetry)

Effect: Normal conscious state, normal performance

Cause: Parallel Operating Mode (4D VCM Symmetry)

Effect: Flow state, peak performance, in The Zone

Sport and vision scientists have typically approached this cause/effect relationship from a reproduction of the effects. If the effects are reproduced, the chances of reproduction of the cause are increased. The parallel mode approaches this relationship, but from a causal direction. By reproducing the underlying cause of The Zone, resultant effects can also be reproduced. In human action, the resultant effects are the flow components of The Zone.

This parallel mode model defines the underlying cause of higher-order performance through an explanation of the operational architecture of 4D-VCM Symmetry – an architecture whose uniquely ordered IPO interface can maximize human potential in volleyball when vision is a primary element. Thus, this model has enormous potential in volleyball because every experience can be performed in either a serial or parallel mode.

Parallel mode involves the creation of the peak performance state, often referred to as “The Zone,” by recreating the underlying VCM dynamics of the operating system in a flow state. The Zone is the higher-order performance state in which athletes transcend their ordinary performance levels and enter the realm of maximum human potential.

Elite athletes, such as Karch Kiraly and Karen Kemner, have reported being in The Zone at different times in their careers. When interviewed, they recall a performance state of complete focus and total concentration in which important performance elements converge with effortless efficiency.

For years, sport scientists have studied this peak performance state, and even the most recent investigations have come to similar conclusions. In essence, the flow characteristics of The Zone are well defined, but any underlying cause of The Zone has yet to be determined. Jackson and Csikszentmihalyi (1999) have suggested that “it is impossible to give a generic recipe...it is not a state of mind that can be manufactured and distributed in packaged form” (p. 161).

One of the defined components of the traditional flow model is a lack of self-consciousness. This lack has led to the belief that The Zone cannot be created by the conscious self. Athletes, according to this perspective, cannot make The Zone occur; they can only prepare for it by bringing together as many of the flow components as possible. Therefore, according to flow theory, it is impossible for humans to control The Zone.

The parallel mode model is a different theoretical model for human peak performance. It is based on the self-organization of the underlying VCM dynamics of the operating system into a four-dimensionally symmetrical IPO interface. This symmetrical interface is the cause of the peak performance state known as The Zone.

Several definitions of terms, phrases, and constructs will help to understand the parallel mode model.

*Four Dimensions:* The three dimensions of space: height, width, depth, and time.

*Contact Sequence (CSQ):* The orderly succession in space and time of the movement of the object (mvt), the performer’s movement to intercept the ball (cmvt), and contact (cnt), the event that occurs when both movements come together at a common point in space and time. This contact sequence has also been referred to as coincidence anticipation time, involving object movement, performer movement, and the exact moment in time and space when object and performer coincide.

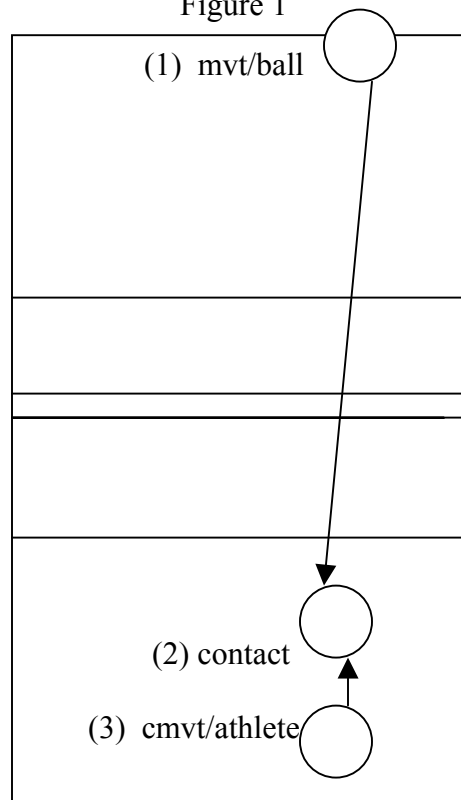
Mvt ->Cmvt->Cnt  
1 ->2 ->3

Volleyball is a game of movement, countermovement, and contact. Figure 1 illustrates the concept of the contact sequence in volleyball.

This contact sequence is the fundamental building block. Each individual contact sequence can be considered a discrete event, having a beginning, middle, and end. Every contact sequence begins with the movement of the ball (mvt), followed by the athlete’s movement to intercept the ball (cmvt), and ends with contact (cnt), the event that occurs when object movement and performer movement (cmvt) come together at a single point in space and time – the contact point.

Mvt -> Cmvt -> Cnt  
1 ->2 ->3  
Ball ->Athlete->Contact

Figure 1



*Contact Event:* The moment of contact. It can be positive or negative. Positive contact perpetuates the rally and keeps the point going, while negative contact ends the rally and/or the point. The objective of performer movement (cmvt) is to create positive contact. Specifically, the athlete's VCM operating system is a system of countermovement in a movement versus countermovement relationship in space and time. The accuracy with which the VCM operating system relates in space and time to the movement of the ball determines the quality of contact.

*Asymmetry:* The unequal distribution of parts around a common center or axis, or on opposite sides of a dividing line.

*Symmetry:* The equal distribution of parts around a common center or axis, or on opposite sides of a dividing line.

*Four-Dimensional Asymmetry:* The unequal distribution of spatial and temporal dimensions around a common center or axis, or on opposite sides of a dividing line.

*Four-Dimensional Symmetry:* The equal distribution of spatial and temporal dimensions around a common center or axis, or on opposite sides of a dividing line.

*Depth of Contact:* The 4D area of space and time located in front of the athlete in which potential contact events can occur.

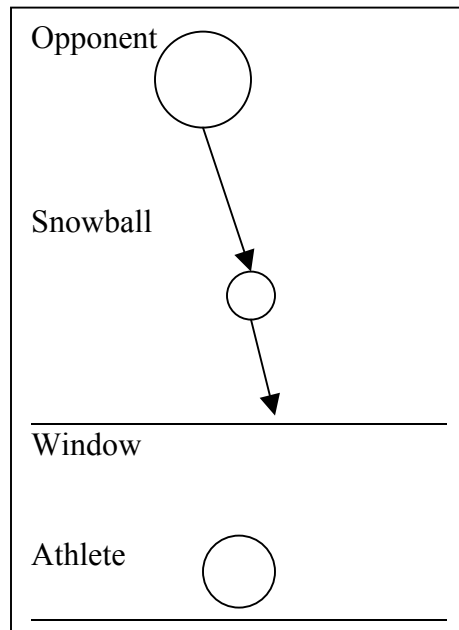
*Visual/Cognitive/Motor Operating System (VCM):* The VCM operating system is an Input/Processing/Output (IPO) continuum. The eyes input 4D visual information to the brain about the direction and speed of the ball's movement. The brain receives the

4D information, processes it, and outputs meaningful 4D motor information that, in turn, is translated into countermovement that relates in direction and speed to the movement of the ball. The more accurately and efficiently the eyes input 4D visual information to the brain about the direction and speed of the ball, the greater the athlete's spatial and temporal performance accuracy. The human operating system, utilizing the IPO continuum, is capable of performing these relational countermovements in radically different 4D VCM operating modes. A serial operating mode utilizes the 4D VCM architecture underlying the normal human performance state, while a parallel operating mode utilizes the 4D VCM architecture underlying the peak human performance state, The Zone.

Visual System Input: Higher-order performance begins with higher-order visual system input. The following analogy demonstrates the difference between the serial input pattern of the normal performance state and the parallel input pattern of the peak performance state.

Imagine looking through a large picture window as a person throws a snowball at the window. A contact event will occur exactly when and where the snowball meets the window...SPLAT! In this scenario, the objective of the visual system is to locate the contact event along the surface of the window; to have the SPLAT in focus when and where it happens.

Figure 2



The standard visual strategy for locating the contact event in this situation is to “watch the ball” or, in this case, “watch the snowball” as it traverses along its flight path from start to finish. If the snowball is in focus throughout its entire flight path, the snowball will be in focus when and where it splats against the window. The contact event is located by focusing on the snowball, the object of movement.

Watching the snowball in this situation is referred to a varying focus, or utilizing a variable depth of focus input pattern (VDF). VDF requires refocusing the eyes from distance to near in order to keep the object of movement in focus from beginning to end.

Alternatively, a fixed depth of focus input pattern (FDF), accomplishes the same visual objective of locating the contact event by using a different visual strategy. Instead of focusing on the snowball and consistently tracking it to the window, the eyes are focused on the window, searching for the contact point along the window's surface. Rather than locating the contact event by focusing on the object of movement, the contact event is located by focusing on the depth of contact zone, the window itself.

The major difference between VDF and FDF input lies in the efficiency of each pattern. VDF input (tracking the ball) requires numerous fixations (or saccades) as the ball moves along its flight path. This visual pattern of continuous refocusing involves both the rotational and refocusing countermovements of the eyes. This dynamic state of flux converts to two visual variables: rotation and depth of focus.

With FDF input (locating the contact point along a predefined depth of focus), the refocusing countermovement of the eyes is no longer a variable. By fixing focus on the window/contact zone, the refocusing variable is converted to a focusing constant. The rotational countermovement of the eyes still remain a variable as they locate the contact point along the fixed depth of focus. By prefocusing on the contact zone, the refocusing variable is effectively eliminated by making it a constant. Prefocusing eliminates continuous fixations, and with the elimination of the refocusing variable comes the elimination of a major cause of input error.

In terms of efficiency, a VDF input pattern is represented as:

VDF visual countermovements

1. rotation: variable
2. focus: variable

Efficiency factor: 2 variables

The FDF input pattern is represented as:

FDF visual countermovements

1. rotation: variable
2. focus: constant

Efficiency factor: 1 variable; 1 constant

When viewed from the systems efficiency perspective, the difference between VDF and FDF input is the difference between an input pattern with two variables versus an input pattern with one variable and one constant. Basic systems analysis supports the notion that any system accomplishing the same objective as another system, but with fewer variables, is a more efficient system. In short, a fixed depth of focus input pattern is a more efficient way to locate the contact event than a variable depth of focus input pattern.

*Input Accuracy:* The human eye cannot continuously track a ball at a relative velocity greater than 70 degrees/s (Bahill & LaRitz, 1984; Adolphe, Vickers, & Laplante, 1997). This inability to continuously track a fast-moving ball results in incorrect input information during the visual/perceptual process. Traditional visual input patterns are based upon keeping the fast-moving ball in focus. The end result continues to be inaccurate information from inaccurate visual countermovement relative to the movement of the object of focus (the ball).

The inaccurate refocusing countermovement of the eyes causes reception of inaccurate information about the actual speed of the ball. As a result, the relative output speed of the athlete's countermovement will be inaccurate in time and space. The result is generally negative contact. The last link of the visual/cognitive/motor chain is performed inaccurately because of temporal and spatial inaccuracies occurring in the first link, the initial visual input. Inaccurate motor output is caused by inaccurate visual input.

A fixed depth of focus input pattern within the contact zone, then, may provide a critical piece of information for performance success when vision is a primary element. It is not only more efficient than variable depth of focus, but is also more accurate.

*4D Visual Symmetry vs. 4D Visual Asymmetry:* Every contact sequence in volleyball contains a relationship between movement and countermovement that is both spatial and temporal in nature. The spatial relationship is the relationship between the height, width, and depth of the ball's directional movement through space relative to the height, width, and depth of the athlete's directional countermovement through space. This timing relationship has also been referred to as coincidence anticipation time between ball movement and athlete countermovement.

The more accurately the athlete's eyes can input this four-dimensional movement information, the more accurately the athlete's brain will output four-dimensional countermovement information through the central nervous system to the musculature.

Variable depth of focus is asymmetrical in the distribution of the four-dimensional information about the direction and speed of the ball's movement. The spatial distribution of a VDF input configuration is represented as:

< - VDF                      VDF = variable depth of focus inpatterning depth of mvt  
 mvt - > cmvt - > cnt  
 - < R                          R = rotation inpatterning height and width of mvt

Visual countermovements dedicated to the spatial location of movement - 2  
 Visual countermovement dedicated to spatial location of contact - 0  
 Distribution pattern: Location of movement - 2 / Location of contact - 0

This is the unequal visual distribution of spatial information about the elements of the contact sequence: spatial asymmetry

The spatial distribution of FDF input configuration is represented as:

FDF - >                      FDF = Fixed depth of focus inpatterning depth of contact  
 Mvt - > cmvt - > cnt  
 - < R                          R = rotation inpatterning height and width of mvt

Visual countermovements dedicated to the spatial location of movement - 1  
 Visual countermovements dedicated to the spatial location of contact - 1  
 Distribution pattern: Location of movement - 1 / Location of contact - 1

This is the equal visual distribution of spatial information about the elements of the contact sequence: spatial symmetry.

In summary, the difference in spatial distribution between VDF input and FDF input is the difference between spatial information dedicated only to the location of movement vs. spatial information dedicated to the location of movement and the location of the contact zone simultaneously.

*Contact Sequence and Time:* In every contact sequence in volleyball, there exists not only the aforementioned spatial relationship between the elements of the contact sequence, but also a temporal relationship, a relationship in time between movement, countermovement, and contact. The athlete, as countermovement, is the “present.” The athlete, then, represents the present temporal element of every contact sequence.

Movement in every contact sequence occurs before countermovement (the present). Therefore, movement is the “past” relative to the athlete. The ball is the past temporal element of every contact sequence.

Contact, in every contact sequence, occurs after countermovement (the present). Therefore, contact is the “future” relative to the athlete. Contact is the future temporal element of every contact sequence.

The temporal relationship of the elements of every contact sequence is represented as:

Mvt - > cmvt - > cnt  
Ball - > athlete - > contact  
Past - > present - > future

*Temporal Asymmetry:* When athletes focus on the ball (VDF input), both visual countermovements (rotation and VDF) are used to input temporal information about movement only. This means that both visual countermovements are used to input temporal information to the brain about the past only.

The temporal distribution of a VDF input configuration is represented as:

< - VDF                      VDF = VDF inpatterning information about past movement  
mvt - > cmvt - > cnt  
past - > present - > future  
< - R                              R = rotation inpatterning info re: past movement

Visual countermovements dedicated to past movement - 2  
Visual countermovements dedicated to future contact - 0  
Distribution pattern: Past – 2 / Future – 0 = Past

This is unequal distribution of the temporal elements of the contact sequence around the common temporal axis of the athlete: temporal asymmetry.

*Temporal Symmetry:* In comparison, FDF input involves a completely different distribution pattern of the temporal information in every contact sequence. When an athlete fixes focus on the contact zone and locates the contact point along this predefined depth of focus, the available temporal information is distributed equally on both sides of the temporal axis of countermovement. By simultaneously inputting equal temporal information about the ball’s movement and the depth of contact (FDF), the athlete effectively inpatterns equal temporal information about past and future simultaneously. The athlete’s brain receives equal distributions of the past and the future simultaneously, creating a third dimension, the dimension of the “present.”

FDF - > FDF = FDF inpatterning information about future contact  
 Mvt - > cmvt - > cnt  
 Past - > present - > future  
 < - R R = rotation inpatterning info re: past movement

Visual countermovements dedicated to past movement - 1  
 Visual countermovements dedicated to future contact - 1  
 Distribution pattern: Past - 1 / future - 1 = Present

This is the equal distribution of the temporal elements of the contact sequence around the common temporal axis of the athlete. Result: Temporal Symmetry.

Temporal distribution of the contact sequence in space can be displayed as:

Mvt - > contact < - cmvt  
 1 - > 3 < - 2  
 past - > future < - present

In volleyball, the temporal relativity of the contact sequence is represented as:

Figure 3

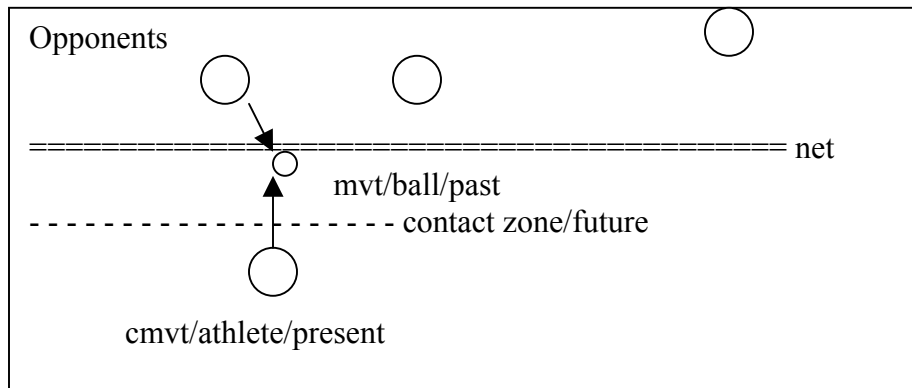


Table 1 is a comparison of VDF input and FDF input. VDF is a four-dimensionally asymmetrical visual input pattern and represents the normal performance state (being in the past). FDF input is a four-dimensionally symmetrical visual input pattern and is the higher-order input pattern in the peak performance state (being in the present) when vision is a primary element.

TABLE 1  
VDF Input vs. FDF Input

1. Efficiency	R = Variable/VDF = Variable 2 variables	R = Variable/FDF = Constant 1 variable/1 constant
2. Accuracy	Refocus = Variable	Prefocus = Constant
3. CSQ distribution	mvt only = asymmetry	$\frac{1}{2}$ mvt / $\frac{1}{2}$ cnt = symmetry
4. Spatial distribution	hw = mvt / d = mvt spatial asymmetry	hw = mvt / d = cnt spatial symmetry
5. Temporal distribution	R = past / VDF = past Past/Past = Past Temporal Asymmetry	R = past / FDF future Past/Future = Present Temporal Symmetry

*Summary:* As the first link of the VCM operating chain, the human visual system is capable of inpatterning visual information to the brain in different 4D input patterns: VDF input pattern (4D visual symmetry), VDF input pattern (4D visual symmetry), or in combination. The visual input pattern used by the athlete in every contact sequence determines the efficiency as well as the accuracy of the available information being formulated in the brain. More importantly, it also determines the temporal dimension in which the athlete performs countermovements within the space and time of every contact sequence. A VDF input pattern engages the athlete in the past temporal dimension during the contact sequence (temporal asymmetry), while a FDF input pattern engages the athlete in the present temporal dimension during the contact sequence (temporal symmetry). The end result for the athlete equals countermovement in the “past” (normal performance state) vs. countermovement in the “present” (peak performance state) when vision is a primary element.

### **Coaching Implications**

Serve reception can be used to illustrate this theory. In traditional visual tracking, the athlete would be asked to focus on the ball throughout its trajectory from the server’s hand at contact to contact with the forearms. When a volleyball travels faster than 70 degrees per second of arc, the athlete is unable to continuously track it. Therefore, it becomes physiologically impossible for the athlete to remain in the present. Variable depth of focus (VDF) must be the strategy of choice employed to track the ball from hand contact to forearm contact. Utilizing a fixed depth of focus (FDF) requires the athlete to initially focus on the “window” which is approximately arms’ distance away from and in front of the body. Utilizing peripheral vision to determine direction and speed of the oncoming ball, the athlete is free to contact the ball at the point of contact where the ball hits the window in time and space. The athlete is able to temporally and spatially contact the ball in the “present.”

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