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Shaping decisions in volleyball

An ecological approach to decision-making in volleyball passing

ANNEMIEK D. BARSINGERHORN, FRANK T.J.M. ZAAL, HARJO J. DE POEL, *and* GERT-JAN PEPPING*

Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, Groningen, The Netherlands

To extend research on decision-making in sport we addressed the choices volleyball-players are faced with in a simple volleyball pass-return task. We manipulated the distance that eight experienced volleyball players had to cover for successful ball passing, and mapped their passing technique (i.e., overhead or underhand) and ball return accuracy in a choice condition. Passing accuracy was then compared with conditions in which reception technique was imposed by instruction. When players were free to choose their technique the landing zone of the ball influenced the choice of technique: When a ball landed further away, the adoption of underhand technique increased, especially for balls that landed in front of the participants. Furthermore, in all conditions the accuracy of the pass decreased with increasing distance to be covered. These results are discussed vis-à-vis the idea that player behavior is shaped by affordances (i.e., possibilities for action). It is argued that to understand decision-making in dynamic sport situations we need to understand how players deal with competing affordances.

KEY WORDS: Affordance competition hypothesis, Ball sports, Embodied cognition, Field experiment, Perception-Action, Volleyball service.

Volleyball is a complex sport in which players need to make many decisions within very short periods of time. Players are typically faced with many action opportunities out of which they (need to) select one that is optimal (or at least pertinent) for the situation. That is, volleyball players have to choose *continuously* out of the possibilities their environment offers. An important question for volleyball then is: how do players come to adopt an appropriate action in a particular situation? For instance, after the service, a critical task of a defending volleyball player is to move to and arrive at a particular position in the court in order to pass the ball to the setter. The demands of arriv-

Correspondence to Gert-Jan Pepping, Center for Human Movement Sciences, University of Groningen, A. Deusinglaan 1, 9713 AV Groningen, The Netherlands. (E-mail: g.j.pepping@gmail.com)

ing at the right place in the right time in such situations depend on many factors such as the maximal movement speed of the player, the available time, and the flight trajectory of the ball in relation to the player. In volleyball, players can additionally use different techniques to pass the ball. In this paper, we investigated the actions that volleyball players naturally adopt in a simple ball reception and passing task.

Decision-making in sport has been a popular topic of study and different aspects of decision-making have been investigated. Focus has been on visual search strategies necessary for decision-making (e.g., Farrow & Abernethy, 2003; Savelsbergh, Williams, Van der Kamp, & Ward, 2002), knowledge bases necessary for decision-making (e.g., MacPherson & Kernodle, 2003; Williams & Davids, 1995), the role of practice in decision-making (e.g., Kibele, 2006; Poolton, Masters, & Maxwell, 2006; Raab, 2002, 2003), and decision-making as an option-generation process (e.g., Johnson & Raab, 2003). The majority of these studies have taken a determinate world view, and adopted reductionist, closed-systems analyses in which the major aim of decision-making is described as the reduction of uncertainty through testing the causal relationship formed by related phenomena in "closed systems" (for an elaborate discussion, see Araújo, Davids, & Hristovski, 2006). In these approaches there is a strong underlying assumption that decisions require conscious processes, implying that athletes make their decisions in a conscious way, and that they are able to reliably report them to others. Also in the scant research on decision-making in volleyball this assumption has been prevalent. For instance, Raab, Gula, and Gigerenzer (2012) studied decision-making in the context of the "hot hand" belief in volleyball; the belief that a player has a higher chance of making a score after two or three successful shots (hits) than after two or three unsuccessful shots (misses). With regard to decision-making, Raab and colleagues argued that playmakers in particular (i.e. setters in volleyball) use this belief to decide whom to play the ball to. Results showed that both coaches and playmakers were able to detect streaks, and that they relied on them when deciding to whom to allocate the ball.

The assumption that skilled performers make their decisions in a conscious way has been controversial. Research has shown that people cannot completely and accurately report their higher-order mental processes such as reasoning, which are involved in, for example, problem solving and the initiation of behavior (Nisbett & Wilson, 1977), and that retrospective verbalization only allows one to verbalize the reasons and products of this activity (Ericsson & Simon, 1980). In sports science, various studies have suggested that decision-making requires both implicit and explicit processes, and that

verbal reports on implicit processes lag behind what is done and known unconsciously (e.g. Raab, 2003; Poolton et al., 2006; Araújo, Travassos, & Vilar, 2010).

In the current paper we employ an alternative approach to studying decision-making in volleyball, which is rooted in an ecological approach. More specifically, we will consider decision-making as the actualization[1] of affordances, the possibilities for action in the environment that athletes perceive and may act upon (Gibson, 1977, 1979/1986). Gibson (1977, p. 67) defined affordances as "a specific combination of the properties of its substance and its surfaces taken with reference to an animal". In dynamic situations, action possibilities arise and vanish; for instance, a serve in volleyball will be passable at some point in time for some players and not for other players, but will become impassable if a player waits too long. Because of the dynamic character of situations like these, and the according emergent nature of decisions, this has also been referred to as the ecological dynamics approach (e.*g.,* Araújo, et al., 2006; Headrick, Davids, Renshaw, Araújo, Passos, & Fernandes, 2012; Travassos, Araújo, Davids, Vilar, Esteves, & Correia, 2012).

To understand how people come to an appropriate action in a particular situation, researchers have been studying the perception of affordances. After the pioneering empirical work of Warren (1984, 1988), who demonstrated that people are accurate perceivers of their own action boundaries in stair climbing, others have studied the perception of affordances in other tasks as well (e.g. see Mark, 1987; Warren & Whang, 1987; Jiang & Mark, 1994; for a recent review of research on affordances, see Barsingerhorn, Zaal, Smith, & Pepping, 2012). Pertinent to the present study, Pepping and Li (1997, 2000) investigated the perception of affordances in blocking in volleyball, which is an action that depends, amongst other things, on anthropometric characteristics (reach height of the player) as well as kinetic characteristics (jumping ability of the player). Results revealed that participants could accurately judge whether they could reach a ball or not, reflecting that they perceived the boundary of their action possibilities. Follow-up studies showed that when subsequently the action capabilities of the participants were altered (e.g., through manipulation of the participants weight and the ground surface the participants were asked to make the blocking action on), the perceived action boundaries changed accordingly (Pepping & Li, 2000, 2008). Similarly, other studies followed comparable approaches in other

[1] An affordance is said to be actualized when the possibility for a certain action (i.e., the affordance) has indeed led to execution of that action.

sports-related tasks (for overviews of research on affordances in sport see Araújo et al., 2006, and Fajen, Riley, & Turvey, 2009), such as baseball (e.g., Oudejans, Michaels, & Bakker, 1997; Oudejans, Michaels, Bakker, & Dolné, 1996), basketball (Weast, Shockley, & Riley, 2011; Esteves, Oliveira, & Araújo, 2011), and association football (Pepping, Heijmerikx, & de Poel, 2011; Dicks, Davids, & Button, 2010).

In most research on affordances in sport to date, the focus has remained on the perception of the action boundary of a single specific action, that is, the ability to *perceive* if that action is possible or impossible. However, in many sports situations players have *multiple* options and solutions to reach their goal. For instance, as a function of the distance to the target, soccer passes are executed with different techniques (Pepping et al., 2011) and boxers show different punching actions (Hristovski, Davids, Araújo, & Button, 2006). Interestingly, these studies showed that some passer-target and boxer-target distances afford a single passing technique or punching action but that other distances afford multiple actions. That is, multiple actions are afforded *concurrently*. Similarly, in cricket, batters' shot direction was strongly related to the position of ball bounce for most pitches, but some regions of ball-bounce position afforded widely varied shot-directions (Pinder, Davids, & Renshaw, 2012). In volleyball, players also have multiple techniques at their disposal to address an incoming ball (e.g., a service): they can choose to pass the ball with an underhand technique or decide to use an overhead technique for passing the ball. Little is known about what determines the actual execution of a (service) pass in volleyball. That is, why do players sometimes choose to play a ball with the underhand technique and at other times with the overhead technique? Therefore, the main aim of the present study was to explore factors that shape the performance of volleyball passing. We argue that it is not solely a matter of technical passing abilities, but rather, a matter of how the specific situation (in this case ball trajectory relative to passer position) *affords* certain behavior (in this case passing technique). That is, affordances *shape* decisions for a particular passing technique and thereby comply how a pass is executed (cf. Araújo et al., 2006; Hristovski et al., 2006; Pepping et al., 2011; Travassos et al., 2012).

In the current study, we addressed decision-making in volleyball in a task in which experienced volleyball players were asked to pass approaching volleyballs. One of the factors that could influence whether and how a ball is passed is the accuracy of the techniques at disposal of the player; the accuracy of each technique might be related with the distance the player has to cover to reach the ball, and the distance to the setter at the moment of passing. As an example, when a ball landing far away can only be intercepted at

a height below the waist, it is rather impossible to deliver an accurate pass by means of an overhead technique. Furthermore, for obvious biomechanical reasons, balls landing in front of the player imply different affordances, and hence might show different performance than balls landing behind the player. Therefore, the choice for a specific technique was examined in relation to the accuracy of the players' different techniques at different locations on the field.

Method

Participants

Eight experienced volleyball players (three men and five women, aged 21±1.2 years) were recruited to participate in the experiment. All players had played volleyball for at least four years (on average 8.4±3.9 years), and were currently playing at higher regional levels. The experiment was conducted in grouped sessions with two or three participants present. All participants had normal or corrected to normal vision. The study was approved by the Human Movement Sciences Ethical Board of the University Medical Center Groningen, University of Groningen. Participants signed an informed consent form before the start of the experiment.

Experimental setup and procedure

The experiment took place on a standard volleyball field in an indoor gym, and was performed in a training setup. The participants' task was to pass a ball to a "setter". At the start of each trial, a participant was standing on the middle of a 9-meter line that started at the location of the net, and ended at the backcourt boundary of the volleyball court. The participant started with both feet at a marker indicating the starting position, with the arms stretched alongside the body. The participants were allowed to move backwards and forwards along this line, and they returned in starting position after each trial. The line was divided into seven zones of 1.28m each (see Figure 1). To assure that each ball was delivered in the assigned zone, and to enable accurate post-experimental data coding these zones as well as the starting location were marked with tape on the floor. Although the net was absent, the line marking the location of the net was visually present on the ground. A second person, the "server", was standing on the 3-meter-line on the other half of the volleyball court, i.e., at a 7.5 m distance from the participant (i.e., the receiver). The "server" was instructed to throw the balls with an arc into the designated zones (see Figure 1a). Emphasis was placed on equally distributing the balls over the seven zones and on throwing the ball to more or less the same height. In general the presented ball trajectories were of sufficient height to pass over a volleyball net. A third person, the "setter", was standing on an area of 1x1.50m close to the location of the net (see Figure 1). The experiment was filmed with a full-HD camera (Canon HF100) capturing full frames with a resolution of 1920 × 1080 pixels at 25 fps. The camera captured the total volleyball field in the sagittal plane. Before each session the image plane was spatially calibrated in order to compute the location of the participants afterwards.

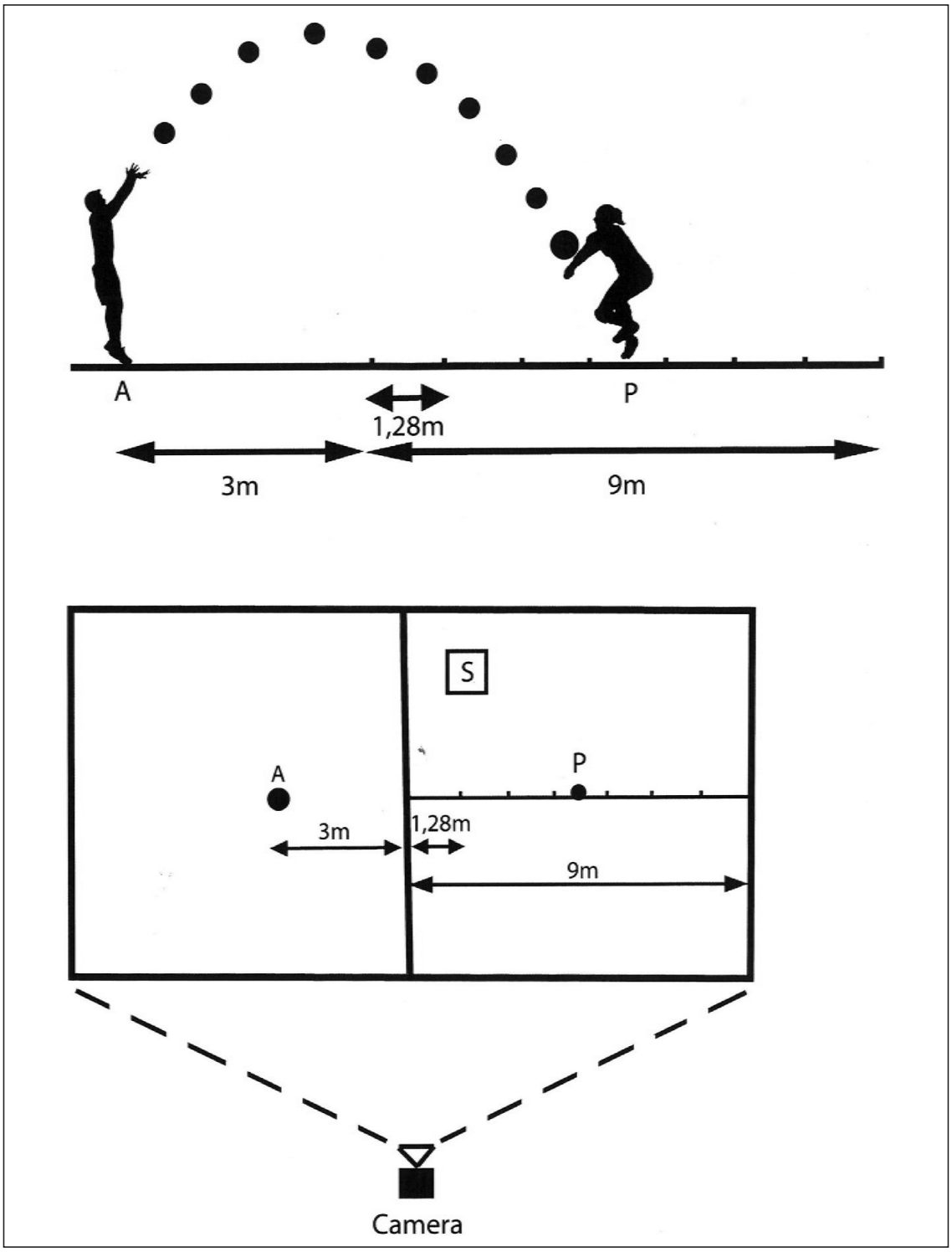

Figure 1. Schematic setup of the experiment. a. Side view with the participant at starting position (P) and the 'server' (A). b. Top view with the starting location of the participant (P) and the location of the 'setter' (S) and the 'server' (A). The boundaries of the seven zones are indicated by the small dashes on the line the participants were moving along.

Design

The experiment consisted of three conditions. In the first condition, the participants were free to use the technique they preferred to pass the ball to the setter ("*choice*" condition). In the "*overhead*" and "*underhand*" conditions (we will also refer to these conditions as the "*instructed-technique*" conditions) the participants were instructed to use a specified interception technique. The overhead technique implies the ball is played at or above eye level using the fingertips, while in the underhand technique the ball is played with the forearms. No restrictions on the execution of the techniques were given. Conditions were presented in blocks of trials. Participants always started with the choice condition block, followed by two blocks of instructed-technique. The order of the overhead and underhand blocks was counterbalanced over participants: half of the participants started with the overhead technique whereas the other half started with the underhand technique. Each block lasted for about eight minutes in which the participants received balls from two different "servers" (for reasons of potential fatiguing effects, the server and setter changed position after about four minutes). During each block the participants played, on average, 71 balls (range 65-81 balls). Between the different blocks the players were allowed to recuperate. During the experiment, one of the experimenters counted the distribution of the balls over the different zones, and a block ended when this experimenter estimated that the participant had played a minimum of 5 balls per zone.

Analysis and variables

The video footage was manually digitized using SIMI-motion software (SIMI Reality Motion Systems, Unterschleißheim, Germany) at the camera's frame rate (25 fps). The moment of launch of the ball, and the moment the ball was passed were registered and used to calculate the flight time of the ball. Furthermore, the location of the center of the ball was selected at the moment the participant came in contact with the ball. This location was used to determine in which zone the ball was played, using the pixel coordinates of the calibration grid. Two observers digitized the video footage. Inter-observer reliability for the different dependent measures was .99 or higher. The independent variable for the analyses was the location of the ball at the moment of passing, categorized in 7 zones, with zone 0 being the zone with the starting location (see Figure 1). Three dependent variables were analyzed: (i) the flight times of the balls, (ii) the technique the players used to pass the ball, and (iii) the accuracy of the pass. For the purpose of the current study, a successful pass was operationally defined as one that the setter could catch without leaving the area he/she was positioned. In line with this definition, the participants were required to pass accurately to the setter (see *Experimental Setup and Procedure*) who was positioned at a small area of the field close to the ideal setting zone (see, e.g., Afonso, Mesquita, Marcelino, & Da Silva, 2010) which, in an actual game situation, would have allowed a setter to be successful in giving the set-up for an attack. For each zone a success rate was computed, defined as the percentage of successful passes. Repeated measures ANOVAs were performed on the dependent variables, with zone as independent variable. Significant main effects of zone were further analyzed using simple contrasts, and zone x condition interaction effects were further scrutinized using planned pairwise comparisons using paired samples *t*-tests with Bonferroni correction. To correct for violations of the sphericity assumption the Greenhouse-Geisser adjustment was used. Overall, α was set at .05.

Results

In total the experiment resulted in 1711 balls played (597 in the choice condition, 549 in the overhead condition, and 565 in the underhand condition). After digitization it turned out that one of the participants, in spite of the observations during the experiment, had not passed balls in zone +3 in the choice condition. Therefore, the repeated measures ANOVAs were performed on data of seven participants, which consisted of 1491 balls played (512 in the choice condition, 481 in the overhead condition, and 498 in the underhand condition).

Ball flight times

Figure 2 shows that ball flight times were around 1.5s. The flight times ranged from a minimum of 1.44s in zone -1 to a maximum of 1.73s in zone +2 in the choice condition, from a minimum of 1.50s in zone -1 to a maximum of 1.73s in zone +2 in the overhead condition, and from a minimum of 1.43s in zone -1 to a maximum of 1.69s in zone +2 in the underhand condition. A repeated measures ANOVA performed with flight time as dependent variable, and zone and condition as independent variables revealed a main effect of zone on the flight time, $F(1.73,10.39) = 15.63$, $p = .001$, $\eta_p^2 = .723$, but no significant differences between the three conditions, and no significant interaction effects.

Preferred techniques in the choice condition

The first aim of the experiment was to explore the interception technique that volleyball players adopt when they are free to use their technique. First we calculated the percentages of overhead and underhand passes per zone for each participant. The collapsed data over all the participants resulted in the distribution of the techniques used presented in Figure 3. As can be observed in this Figure, a high incidence of the underhand technique was observed in the zones in front of the initial location of the participants. Around the starting location (zone 0) and the zones just behind (zone +1 and zone +2) the percentage overhead passes increased, leading to a distribution where the two techniques were more equally distributed. In zone +3 a high percentage of underhand passes was observed. This was supported by a repeated measures ANOVA performed on the percentage overhead passes that revealed a significant main effect of zone

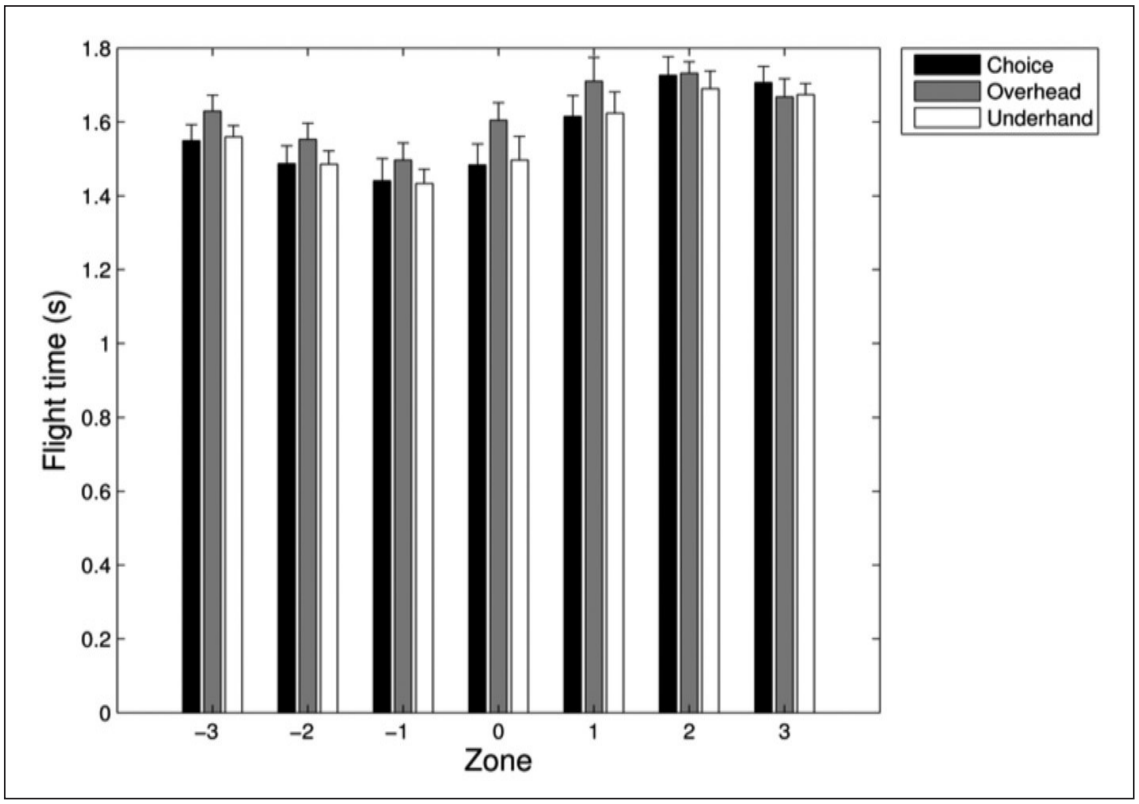

Figure 2. The distribution of the flight times of the balls over the seven zones for the three conditions (means and standard errors).

on the technique used to pass the ball, $F(2.70,16.27) = 18.64$, $p <. 001$, $\eta_p^2 = .757$. Comparisons of each zone with its neighboring zone(s) revealed that from zone -1 to zone 0 the percentage overhead passes increased significantly, $F(1,6)=18.77$, $p = .005$, $\eta_p^2 = .758$, and from zone +2 to zone +3 the percentage overhead passes decreased significantly, $F(1,6) = 31.88$, $p = .001$, $\eta_p^2 = .842$.

Accuracy of the passes

From the 512 passes in the choice condition, 400 were counted as successful (i.e., 78%). Figures 3 and 4 show how accuracy was different across the zones. High success rates were observed in zones -2 to +2, with percentages successful passes ranging from 67 to 95 percent. In zone -3 the success rate was 55 percent and in zone +3 only 33 percent of the passes reached the setter. Indeed, a repeated-measures ANOVA performed on the data of the choice condition revealed a significant effect of zone on the success rate,

$F(6,36) = 10.42$, $p < .001$, $\eta_p^2 = .634$. When comparing each zone with the neighboring zone(s) using simple contrasts, we found a significant increase of successful passes from zone -3 to zone -2, $F(1,6) = 34.08$, $p = .001$, $\eta_p^2 = .850$, and a significant decrease in the percentage successful passes from zone +2 to zone +3, $F(1,6) = 6.66$, $p = .042$, $\eta_p^2 = .526$.

When participants were instructed to use a specified technique, a total of 979 balls were intercepted successfully: 380 out of 481 balls in the overhead condition (i.e., 79%), and 392 out of the 498 balls played in the underhand condition (i.e., 79%). As can be observed in Figure 4, high success rates were observed in zones -2 to +2 for both conditions. A repeated measures ANOVA with the success rate as dependent variable and with zone (-3 to +3) and condition (overhead and underhand) as independent variables revealed a significant main effect of zone, $F(6.36)=24.57$, $p<.001$, $\eta_p^2 = .804$, and a significant condition zone interaction effect, $F(6,36) = 4.75$, $p = .001$, $\eta_p^2 = .442$. To unpack this interaction effect, we compared the success rates of both techniques for each zone separately. Paired t-tests showed a significant difference only in zone -3, $t(6) = 4.04$, $p = .007$, indicating higher accuracy when instructed to use the underhand technique.

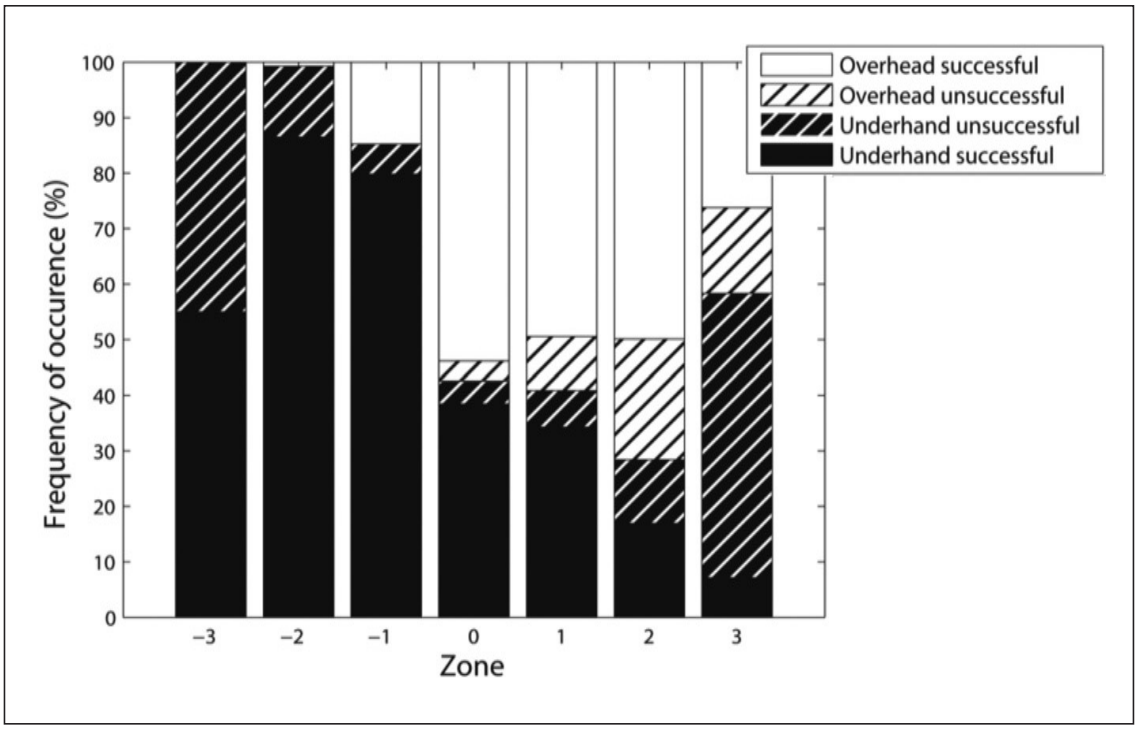

Figure 3. The distribution of the technique used in the choice condition including the accuracy of the passes displayed for the seven zones.

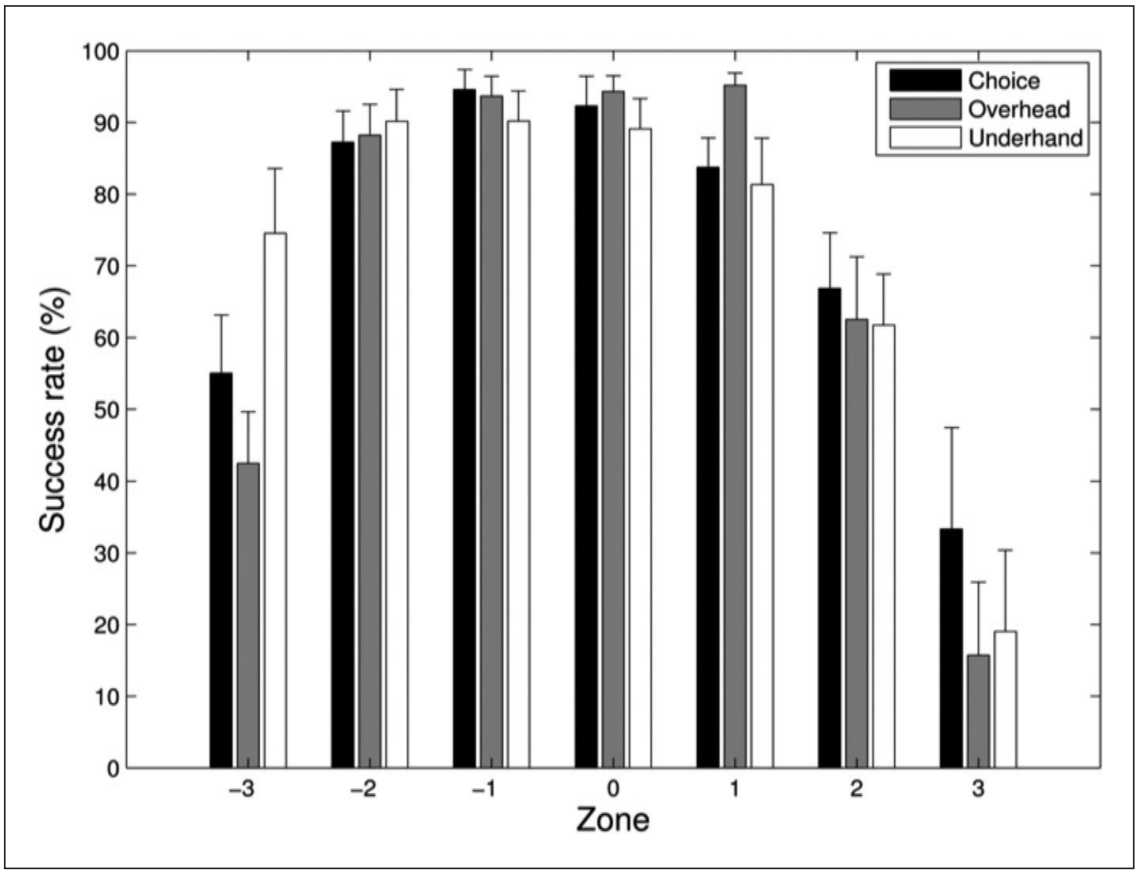

Figure 4. The distribution of the success rates of the passes over the seven zones for the three conditions (means and standard errors).

Discussion

In the current study, we investigated decision-making in volleyball from an ecological approach by examining affordances in an actual volleyball-passing task. The main questions that we addressed were: what actions do volleyball players naturally select in a simple ball reception and passing task, and how can the volleyball players' decision-making in these situations be explained in terms of affordances? We manipulated the distance to be covered by participants by projecting balls in designated landing zones relative to a fixed player starting position. In other sports, distance has proven to be a powerful factor to manipulate affordances (e.g., Hristovski et al., 2006; Pepping et al., 2011; Pinder et al., 2012).

As could be expected when players were free to choose their technique, the landing zone of the ball influenced the technique the participants used. An important finding was that at most distances, the players used both tech-

niques to reach their goal. This finding shows that at these distances multiple affordances existed; that is, multiple actions were afforded concurrently, as has also been shown in other sports (Hristovski et al., 2006; Pepping et al., 2011; Pinder et al., 2012). At some distances, though, players did show a preference for adopting one particular technique. For balls in the zones farthest in front of the starting position of the players (zones -3 and -2), underhand passes were observed almost exclusively. In the zone directly in front of the participants players (zone -1) also preferred the underhand technique whilst also the overhead technique was occasionally used. In the zones where the players started and those directly behind the starting position (zones 0, +1, and +2), a more or less even distribution of techniques was used. Finally, in the zone farthest behind the players (zone +3) they showed a preference for the underhand technique. Inspection of the video footage learned that in this zone the participants often turned around and played backwards using the underhand technique. It is likely that this resulted from the fact that participants could not run backwards fast enough.

As also could be expected, the distance to be covered by participants had an effect on the accuracy of the passes. In short, the accuracy of the pass decreased with increasing distance to be covered. Participants were most inaccurate in the zones farthest in front and behind their starting position. Accuracy increased when balls arrived closer to the starting position of the participants. Noteworthy is the finding that in the zone farthest behind the participants the vast majority of balls could not be returned accurately to the setter.

When participants were instructed to play a prescribed technique, data revealed that it was not simply the location of the player at the moment of playing and the technique used that affected playing accuracy. Whereas in the zone farthest in front of the starting position (zone -3) participants were significantly more accurate when using the underhand technique, in all other zones participants' accuracy was relatively independent of the prescribed technique; it followed a pattern similar to that found in the choice condition, with accuracy increasing when balls arrived closer to the starting position.

The present study failed to show differences in terms of accuracy between the techniques in most zones. This finding is in line with previous work (Palao, Manzanares, & Ortega, 2009), in which a number of matches of several National teams were studied. Palao and colleagues determined the techniques that players used in many situations during the game. With respect to serve reception, they found that an underhand technique was used in most cases (cf. Ureña, Calvo, & Gallardo, 2000), but they did not find a difference in the quality of the reception between an overhead and an under-

hand reception. That is to say, when considering these two techniques beyond serve reception, overhead passes turned out to be more accurate than underhand passes, but this accuracy difference was not seen in serve reception. Palao et al. proposed that, in general, overhead passes allow more precision, but are also primarily suited for "easier" balls, such as passes arriving in the frontal plane (Koch & Tilp, 2009), and for slower balls.

When allowed the choice in the zone farthest in front of them (i.e. zone -3), participants exclusively used the underhand technique, the technique with highest accuracy in the constrained conditions. Interestingly, in this zone the success rate in the choice condition was only 55 per cent, whereas it was 74 per cent in that same zone when participants were constrained to use that same underhand technique. In other words, when participants were free to choose their technique, their success rate for balls landing far in front was lower. This seems a counterintuitive finding. One reason for this effect might be that accuracy suffers simply because a choice has to be made, one between two techniques (i.e., affordances are competing). In other words, some situations in which multiple actions are afforded concurrently (see Hristovski et al., 2006; Pepping et al., 2011; Pinder et al., 2012) might be related with lower success in actually performing the chosen action.

Our study differed from classic affordance research in the sense that we did not solely focus on (perception of) action-boundaries in a situation in which participants are presented with one particular task which is either possible or impossible to execute, depending on the action boundary of the participant (e.g., see Warren & Whang, 1987; Mark, 1987). We were not looking for such critical action boundaries delineating possible from impossible situations or for optimal points at which an action is most effective or comfortable (e.g., see Warren, 1984). Rather, we purposely aimed to contrast the situation in which the participants were instructed to use only one particular technique with one in which participants were free to choose among several afforded options. What became apparent from adopting this approach is that in the choice condition over the whole range of distances that we manipulated (i.e., in all zones) our participants were presented with multiple affordances. The results from the balls landing in the zone farthest in front of the participants (i.e. zone -3) suggest that the affordances that were actualized in the choice condition were a reflection of perception of action capabilities. That is, in that zone, participants used the technique they perceived to be most successful for that situation, as confirmed by our findings in the instructed technique condition. The idea that perception of action capabilities accounted for the shown technique, however, cannot explain affordances actualization and technique selection in the other zones. Taken together, this

suggests that the place that the balls were landing did not constrain the players towards adopting a single technique. Hence, other factors than distance must have played a role to specify a technique in these zones. In this study our manipulations were limited to the distance participants had to cover in order to play the ball. To shed light on how decisions in volleyball are shaped, further research could also manipulate other potential factors of the affordances for passing in volleyball: factors such as the ball flight trajectory, the action capabilities of the volleyball player and the setter (cf. Pepping et al., 2011), the position in the field, and perhaps even tactical choices, to name a few. Ideally, an analysis of the individual action capabilities of the player in relation to the actions they performed (see e.g. Dicks et al., 2010, for such an approach in association football) would give more insight on the emerging decisions in volleyball. Unfortunately, given the low number of trials per participant in the study, an analysis at the individual level would have been unreliable. Considering the individual action capabilities, however, seems a next logical step when trying to understand interception in volleyball from an affordance perspective.

Traditional cognitive theories propose that in natural (sport) behavior the questions "what to do" (action selection) and "how to do it" (action specification) are resolved in a serial manner. That is, action selection (decision making) occurs before action specification (movement planning). The theory of affordances proposes that during natural interactive behavior action selection and specification should be regarded as one and the same dynamic process (see also Smith & Pepping, 2010; Smith, Zaal, & Pepping, 2012, 2013). The results of the current study show that in volleyball often players are faced with situations where multiple actions are afforded simultaneously. To address how people deal with these situations, Cisek (2007) proposed an interesting hypothesis. Drawing on ideas from neuroscience and ecological psychology, Cisek argued that during overt performance of movements the processes of action selection and specification operate simultaneously and continuously: "sensory information arriving from the world is continuously used to specify several currently available potential actions, while other kinds of information are collected to select from among these the one that will be released into overt execution at a given moment" (p. 1586, Cisek, 2007). From this perspective, Cisek (2007) argued, behavior is viewed as a constant competition between affordances (see also Cisek & Kalaska, 2010). Similar to competition between actions, performance accuracy may suffer when multiple actions are afforded concurrently.

In volleyball practice, it is not uncommon to view the different ways in which to address the ball as more or less *separate and distinct* techniques

(e.g., the overhead and underhand techniques). Each technique is considered appropriate for particular, well defined, and separate situations. Such a notion leads practitioners to teach and train volleyball using methods that focus on separate technique execution. The data presented show that this view is limited and that in many instances players used different techniques for similar balls, as well as the same technique for different balls. In other words, the overhead and underhand techniques both produced functional solutions in similar situations as well as in separable situations. Rather than focusing on "correct" (overhead/underhand) technique execution, practitioners could focus more on development of player sensitivity to action boundaries. Further, to develop decision-making skills, it should be encouraged to train different techniques concurrently in situations in which the same techniques are afforded, rather than training different techniques separately.

The aim of our study was not to contrast an affordance approach with traditional cognitive approaches of decision-making. Rather, for the first time in volleyball, we explored what affordances are available to participants in a simple ball passing task and linked them to the actions that volleyball players naturally select when they are free to choose (cf. Araújo et al., 2006). In general, the results illustrate that we can describe the world around us as one that is full of competing action possibilities. Traditional studies on decision-making and affordances exclude gaining insight in the selection and actualization of these competing affordances. A dichotomous view of possible and impossible actions, such as primarily pursued in decision-making as well as the affordance research, is limited in explaining human behavior. The approach and methodology used in the current study open up further paths for decision-making research and practice in volleyball, as well as in other sports.

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