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Faculdade de Desporto

Universidade do Porto

Centro de Investigação, Formação,
Inovação e Intervenção em Desporto
(CIFI₂D)

José Afonso Coelho Neves

**Estratégias percetivas e tomada de decisão em
voleibol. A mediação da perícia e da
representatividade da tarefa.**

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Dissertação apresentada às provas de doutoramento em Ciências do Desporto, nos termos do Decreto-Lei nº 74/2006 de 24 de Março, sob orientação da Professora Doutora Isabel Maria Ribeiro Mesquita e coorientação do Professor Doutor Júlio Manuel Garganta da Silva e do Professor Doutor Andrew Mark Williams.

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Resumo

O estudo da tomada de decisão (TD) no desporto tem sido alvo de um interesse crescente, em particular no contexto dos Jogos Desportivos, fruto do papel nuclear que assume na obtenção de elevadas performances. São, contudo, escassos os estudos realizados em situações representativas do jogo, particularmente no âmbito do voleibol feminino. Deste modo, o objetivo central consistiu em analisar os mecanismos subjacentes à TD em cenários representativos do jogo, no contexto de ações defensivas em voleibol feminino. Foram estipulados os seguintes objetivos específicos: a) indagar as estratégias visuais utilizadas pelas jogadoras face a cenários representativos do jogo, bem como os pensamentos relacionados com a ação que verbalizam; b) averiguar o efeito do nível de perícia sobre os comportamentos visuais e os relatos verbais; e c) aferir se os resultados da pesquisa são influenciados pela representatividade do desenho experimental. Os resultados revelaram a existência de divergências entre a experimentação *in situ* e a projeção de vídeo, quer no que concerne às estratégias de busca visual, quer relativamente aos relatos verbais. Estas divergências podem ser explicadas pelos diferentes constrangimentos proporcionados pelos dois tipos de experimentos, bem como por diferenças no tamanho e dimensionalidade da imagem. A condição *in situ* parece afigurar mais representativa das tarefas reais do jogo, pelo que se recomenda que os estudos futuros procurem adotar esta estratégia de investigação de modo mais regular. Constatou-se, igualmente, diferenças nas estratégias visuais e nos relatos verbais entre as jogadoras peritas e não peritas, com implicações para a construção de modelos balizadores da prática e ilações para a investigação futura. Todavia, a natureza e magnitude dessas divergências diferenciaram-se parcialmente consoante a condição experimental (*in situ* ou projeção de vídeo). Sugere-se que as pesquisas nesta área incorporem desenhos experimentais representativos das situações reais de prática, se possível em condições *in situ*.

Abstract

Research in the field of decision-making (DM) in sport has been capturing a growing interest, especially in Team Sports, where it assumes a core role for achieving high performances. Notwithstanding, few studies have been conducted using representative designs, and more so in female volleyball. Therefore, our main purpose was to analyse the mechanisms underpinning DM in game-representative situations, in the specific context of defensive actions in female volleyball. The following specific goals were established: a) to determine the visual search strategies applied by the players in face of scenarios that are representative of the game, as well as the verbal reports related to their actions; b) to explore the effect of expertise over visual search behaviours and verbal reports under these conditions; and c) to verify if the results are divergent when the task is conducted in a film-based condition versus an *in situ* condition. Results showed differences between the film-based and the *in situ* conditions for visual search strategies and verbal reports. Such differences may be related to the different constraints afforded by the two conditions, namely distinct action possibilities and image size and dimensionality. The *in situ* configures a more representative design, as it more closely resembles the constraints of the game; future research should adopt this paradigm in a more regular manner. Furthermore, differences in visual search behaviours and verbal reports were also linked to the level of expertise, with implications for elaborating models for teaching and practising the game. However, the nature and magnitude of those differences varied according to the experimental condition (*in situ* or film-based). It is suggested that future research should use representative designs, reflecting the task- and context-specific constraints of the phenomenon under study, namely conducting *in situ* experiments with tasks of complexity similar to the game.

Résumé

L'étude de la prise de décision dans le sport a été l'objet d'un croissant intérêt, notamment dans le contexte des Jeux Sportifs, en résultat du rôle primordial qui s'arroe dans l'obtention de performances élevées. Toutefois, les études réalisées en situations représentatives du jeu sont rares, particulièrement dans le cadre du volley-ball féminin. Ainsi, l'objectif central a été d'analyser les mécanismes sous-jacents à la prise de décision en scénarios représentatifs du jeu, dans le contexte des actions défensives du volley-ball féminin. Les suivants objectifs spécifiques ont été formulés : a) déterminer les stratégies visuelles utilisées par les joueuses face à des scénarios représentatifs du jeu, aussi bien que les pensées liées à l'action verbalisée; b) vérifier l'effet du niveau d'expertise sur les comportements visuels et les rapports verbaux; et c) évaluer si les résultats de la recherche sont influencés par la représentativité du plan expérimental. Les résultats ont révélé l'existence de divergences entre l'expérimentation *in situ* et la projection vidéo, si bien en ce qui concerne les stratégies de recherche visuelle, comme relativement aux rapports verbaux. Ces divergences peuvent être expliquées par les différentes contraintes fournies par les deux types d'expérimentation, ainsi que par les différences de taille et dimensionnalité de l'image. La condition *in situ* est apparue plus représentative des tâches réelles du jeu, et les futures études devraient plus régulièrement procurer l'adoption de cette stratégie d'investigation. Il a eu, également, des différences dans les stratégies visuelles et dans les rapports verbaux entre les joueuses expert et les non-expert, avec des implications pour la construction de modèles guides de la pratique et des enseignements pour l'investigation future. Néanmoins, la nature et la magnitude de ces différences se sont différenciées partiellement en fonction la condition expérimentale (*in situ* ou projection vidéo). Il est suggéré que les recherches dans ce domaine incorporent des dessins expérimentaux des situations réelles de pratique, si possible en conditions *in situ*.

I. Introdução

1.1. Justificação e pertinência do estudo

O estudo da tomada de decisão (TD) tem suscitado um considerável interesse na comunidade científica, em áreas tão distintas como a aviação (Morrow et al., 2009), a condução de veículos (Wilson, Chattington & Marple-Horvat, 2008), a medicina (Patel, Groen & Arocha, 1990) e o desporto (e.g. Dicks, Button & Davids, 2010; Roca, Ford, McRobert & Williams, 2011). Este crescente interesse deriva do reconhecimento de que a capacidade decisional se afigura uma componente nuclear da performance, nomeadamente no contexto particular dos jogos desportivos (JD) (Baker, Côté & Abernethy, 2003; Garganta, 2009). Neste âmbito, diferentes paradigmas científicos emergiram na abordagem à TD, com destaque para as perspetivas ‘cognitivas’ (cf. Gréhaigne, Godbout & Bouthier, 2001; Mahlo, 1986; McPherson, 1999) e ‘ecológicas’ (cf. Araújo, Davids & Hristovski, 2006; J. J. Gibson, 1979; Passos, Araújo, Davids & Shuttleworth, 2008) que, mais do que antagónicas, se afiguram complementares.

No desporto, as decisões são tomadas em ação (Araújo et al., 2006), remetendo para uma ligação profunda entre a perceção da situação e a ação. Existem, com efeito, ligações bidirecionais entre perceção e ação que são constrangidas pelas características do sujeito, da tarefa e do envolvimento (Newell, 1986; Oliveira et al., 2009), tornando as *affordances*¹ ajustadas ao corpo e à ação ou, no original inglês, *action-* e *body-scaled* (Fajen, Riley & Turvey, 2009; E. J. Gibson, 2003; Pijpers, Oudejans, Bakker & Beek, 2006). Assim, em JD, os mecanismos percetivos e motores não devem ser estudados isoladamente (Montagne, Bastin & Jacobs, 2008). De facto, é sobejamente reconhecido que o movimento gera informação e modifica os acoplamentos² perceção-ação (J. J. Gibson, 1979; Hristovski, Davids & Araújo, 2009;

¹ *Affordances* são oportunidades de ação para um dado sujeito num envolvimento determinado, constituindo um conceito funcional que explicita as potencialidades de ação em cada situação dada (Gibson, 1979).

² Acoplamento é o ato de criar ligações fortes entre perceção e ação, sendo específicos para cada conjunto de constrangimentos (Mesquita, 2005).

Oudejans & Nieuwenhuys, 2009) — os quais são sempre específicos do contexto (Passos et al., 2008).

No âmbito do estudo da TD, as diferenças entre peritos e não-peritos têm sido amplamente escrutinadas na literatura, através da abordagem centrada no estudo da perícia (Ericsson, Roring & Nandagopal, 2007; Williams & Ericsson, 2005). A investigação empírica salienta diferenças qualitativas na representação da informação entre peritos e não-peritos (Behrmann & Ewell, 2003). Nomeadamente, os peritos detetam mais precisa e rapidamente os padrões de jogo emergentes, mesmo quando as condições experimentais manipulam os acoplamentos percepção-ação (Abernethy, Gill, Parks & Packer, 2001; Laurent, Ward, Williams & Ripoll, 2006), conseguindo ser mais precisos nas suas respostas de antecipação (McRobert, Williams, Ward & Eccles, 2009). Todavia, existem evidências de que a perícia é específica da tarefa e do contexto e que, por isso, exige uma adequada sintonização com os constrangimentos relevantes (Abernethy, Baker & Côté, 2005; Ericsson, 2003; Vicente & Wang, 1998; Williams, Ward, Ward & Smeeton, 2008), dificilmente se transferindo de um domínio para outro (Barnett & Koslowski, 2002; Cañal-Bruland, Mooren & Savelsbergh, 2011). Tais pressupostos sugerem que a pesquisa deve considerar as especificidades da tarefa, caso intente produzir conhecimentos aplicáveis e relevantes para a prática.

A pesquisa sobre TD, utilizando a visualização de filmes, tem permitido discriminar as capacidades táticas de jogadores com distintos níveis de experiência, confirmando nomeadamente que os peritos produzem respostas mais rápidas e precisas (e.g. Vaeyens, Lenoir, Williams & Philippaerts, 2007). Todavia, sabe-se que diferentes condições experimentais produzem distintas respostas, registando-se, inclusive, divergências entre os resultados obtidos para situação de visualização de filmes e cenários *in situ* (e.g. Button, Dicks, Haines, Barker & Davids, 2011; Dicks et al., 2010; Williams, Ford, Eccles & Ward, 2011). Com efeito, a informação fornecida por uma montagem em vídeo difere consideravelmente daquela percebida *in situ*, não apenas porque inibe o comportamento exploratório e restringe a paralaxe do movimento (Raab, Oliveira & Heinen, 2009), mas também porquanto reduz a dimensionalidade e

tamanho da imagem (Al-Abood, Bennett, Moreno Hernandez, Ashford & Davids, 2002; Mann, Williams, Ward & Janelle, 2007) e interfere na percepção de profundidade (Williams, Janelle & Davids, 2004).

Para que os desenhos experimentais sejam representativos (Araújo, Davids & Passos, 2007; Brunswik, 1955), impõe-se a necessidade de respeitar a complexidade das tarefas, evitando a suscetível sobresimplificação que decorre do intuito de lograr um maior controlo ‘artificial’ da situação. Com efeito, quanto maior for a complexidade da tarefa, maior é o efeito da vantagem da perícia, o que vem sendo confirmado em diversos estudos (Jackson, Warren & Abernethy, 2006; Mann et al., 2007; Shim, Carlton, Chow & Chae, 2005; Vaeyens, Lenoir, Williams, Mazyn & Philippaerts, 2007; Williams, Singer & Frehlich, 2002). Do mesmo modo, o tipo de resposta solicitado também interfere com a representatividade do desenho experimental; nomeadamente, a possibilidade de agir fisicamente altera a resposta antecipatória do sujeito, realçando a importância de se utilizar condições experimentais e tarefas que reproduzam, o mais fielmente possível, o envolvimento natural da performance (Bruce, Farrow, Raynor & Mann, 2012; Dicks et al., 2010; Mann, Abernethy & Farrow, 2010). A investigação sublinha, concludentemente, a necessidade da pesquisa recorrer a desenhos experimentais representativos que permitam generalizar conclusões para envoltimentos de performance (Araújo et al., 2007; Dicks et al., 2010; Ericsson & Ward, 2007; McRobert, Ward, Eccles & Williams, 2011; Roca et al., 2011).

A investigação sobre a perícia em TD no âmbito dos JD tem confiado extensivamente na análise dos comportamentos oculares para inferir fatores atencionais envolvidos na performance em diversas habilidades desportivas, servindo-se do seguimento dos movimentos oculares ou *eye-tracking* (Mann, Coombes, Mousseau & Janelle, 2011). Tal deve-se à reconhecida ligação entre atenção e fixação visual, dado que uma mudança no local de fixação tende a ser precedida por uma modificação no *locus* atencional (Mann et al., 2007; Williams et al., 2004). Os estudos comprovam que os peritos realizam menos fixações oculares. Todavia, estas são mais precoces, têm maior duração e focam-se em localizações críticas muito antes da fase final do movimento ter

início (Huys & Beek, 2002; McRobert et al., 2009; Piras, Lobietti & Squatrito, 2010; Vickers, 2011). Acresce que os sujeitos com proficiência superior recorrem a estratégias perceptivas mais globais (Laurent & Ripoll, 2009; Williams et al., 2011) e económicas (Moran, Byrne & McGlade, 2002). Porém, alguns estudos apresentam resultados de sentido inverso (North, Williams, Hodges, Ward & Ericsson, 2009; Roca et al., 2011; Vaeyens, Lenoir, Williams & Philippaerts, 2007). Nestes casos, as estratégias de procura visual parecem evidenciar uma clara dependência da tarefa e, como tal, podem variar drasticamente de modalidade para modalidade desportiva e, dentro de cada uma delas, de tarefa para tarefa (Mann et al., 2007; Vaeyens, Lenoir, Williams, Mazyn, et al., 2007).

Por outro lado, e apesar das consideráveis vantagens do registo dos comportamentos oculares, no âmbito da compreensão dos processos decisionais, sabe-se que o local de fixação, bem como a duração dessa fixação, podem não corresponder linearmente aos locais de onde a informação está a ser capturada, nem mesmo à quantidade de informação processada (Corbetta, 1998; Mann et al., 2007; Vickers, 2009). Adicionalmente, o aumento do nível de perícia parece beneficiar a utilização do controlo visual periférico, vestibular, auditivo, propriocetivo e háptico (Behrmann & Ewell, 2003; Huys & Beek, 2002; Lenzen, Theunissen & Cloes, 2009; Takeuchi, 1993), criando uma menor dependência do sistema visual foveal e tornando-se menos sensível às falhas informacionais decorridas dos movimentos sacádicos (Vaeyens, Lenoir, Williams, Mazyn, et al., 2007). Esta constatação aponta para a pertinência da utilização de métodos complementares que melhor permitam capturar os processos subjacentes à TD, para além das pesquisas centradas no seguimento visual.

Neste sentido, a análise dos relatos verbais constitui uma janela dos processos cognitivos dos atletas durante a competição (McPherson & Kernodle, 2007; Williams & Ericsson, 2005). Estudos recorrendo a este método revelaram que os peritos tendem a exibir representações dos problemas mais avançadas do que os não-peritos, colocando objetivos mais específicos e gerando mais soluções táticas potenciais (McPherson & Kernodle, 2007). Os

pensamentos dos executantes mais evoluídos centram-se em conteúdos relevantes para a tarefa durante a performance (McPherson, 2000). Porém, nem sempre os peritos olham para onde pensam estar a olhar (Moran et al., 2002), podendo surgir um desfasamento entre o que relatam e o que realmente observaram. Por outro lado, uma dificuldade inerente aos relatos verbais passa por saber em que situações os atletas serão capazes de verbalizar o seu conhecimento processual, e em quais não o serão (McPherson, 1994). Deste modo, apesar da sua riqueza, também os relatos verbais colocam limitações quanto ao respetivo poder de análise.

Ressalta, da análise precedente, que estudos que combinem metodologias diversas, procurando validação cruzada das descobertas, são raros na literatura (Casanova, Oliveira, Williams & Garganta, 2009). Nomeadamente, a combinação dos métodos de seguimento visual e de relatos verbais é pouco usual, sobretudo a sua utilização num mesmo experimento (para exceções, consultar McRobert et al., 2011; Roca et al., 2011). Não obstante, torna-se recomendável que a ciência se sirva de uma pluralidade metodológica para capturar o objeto em questão, já que este é configurado por um complexo de relações (Bachelard, 1996; Sousa Santos, 2002), sendo a observância de abordagens múltiplas mais consentânea com a realidade que se pretende analisar (Ericsson & Williams, 2007). No caso do estudo da TD no contexto do desporto, sugere-se a combinação de dados de relatos verbais com dados de seguimento visual (Ericsson & Williams, 2007; McPherson & Vickers, 2004; Williams & Ericsson, 2005; Williams et al., 2004).

1.2. Problema e objetivos do estudo

Os estudos sobre TD em voleibol são escassos. Os trabalhos de Adolphe, Vickers e Laplante (1997), Lee (2010), Piras et al. (2010) e de Vickers e Adolphe (1997) analisam a TD em voleibol masculino, mas exploram apenas os comportamentos visuais dos atletas. No voleibol feminino, destacam-se os estudos de Araújo, Afonso e Mesquita (2011), Botelho, Afonso, Araújo e Mesquita (2011) e Moreno, Moreno, Ureña, Iglesias e Del Villar (2008), embora tendo recolhido apenas relatos verbais. Desta forma, a presente dissertação

constituirá uma investigação pioneira, na medida em que irá explorar a TD no voleibol feminino, cruzando relatos verbais e comportamentos oculares num mesmo procedimento experimental.

O objetivo geral da presente dissertação consiste em analisar os processos subjacentes à TD em voleibol feminino em cenários complexos (i.e., próximos do jogo), no contexto de ações defensivas, temática ainda por explorar na literatura consultada. Sabendo-se que no voleibol feminino, a defesa e o contra-ataque assumem um papel de destaque no resultado final (Palao, Manzanares & Ortega, 2009), no presente estudo a defesa constituiu o momento escolhido para análise.

Para tal, foram estipulados os seguintes objetivos específicos: a) indagar quais as estratégias visuais utilizadas pelas jogadoras quando face a cenários representativos do jogo, bem como os pensamentos relacionados com a ação que verbalizam; b) averiguar qual o efeito do nível de perícia sobre os comportamentos visuais e os relatos verbais das jogadoras; e c) aferir se os resultados da pesquisa relativamente aos comportamentos visuais e relatos verbais das jogadoras são modulados pela representatividade do desenho experimental, nomeadamente no que respeita à sua realização *in situ* comparativamente com a visualização de vídeos.

Com o presente trabalho, pretende-se prover um contributo para o domínio da investigação, relevando o valor e a pertinência decorrentes da realização dos estudos empíricos, com destaque para três domínios: a) a observação de diferenças relacionadas com a perícia em diferentes condições experimentais; b) o cruzamento dos métodos de seguimento visual e de relatos verbais numa mesma condição experimental, fornecendo dados concorrentes e complementares relevantes para a investigação, considerando que a maioria dos estudos recorre apenas a um método; e c) a comparação de métodos *in situ* versus métodos laboratoriais, fazendo emergir as semelhanças e divergências nos resultados obtidos e obtendo-se uma medida da amplitude das diferenças, na convicção de que estes dados serão relevantes para a construção dos desenhos experimentais de futuras pesquisas. Procura-se, adicionalmente, proporcionar subsídios para a prática, nomeadamente

apontando caminhos pertinentes para o desenvolvimento do treino perceptivo-decisional, fruto de um desenho experimental de pesquisa que se pretende representativo das situações de prática.

1.3. Estrutura da dissertação

O capítulo I – Introdução, justifica e legitima a presente dissertação, explicita os seus problemas de pesquisa e propósitos, para além de esquematizar o trabalho a desenvolver.

No capítulo II serão apresentados dois artigos de revisão bibliográfica. No primeiro artigo, aprofunda-se a relação entre a perícia e a TD, explorando-se três mecanismos subjacentes: atenção, antecipação e memória. Nomeadamente, exploram-se as suas características em contextos complexos e relacionam-se com a performance em JD. A dependência destes fatores relativamente a constrangimentos situacionais é investigada e sua complexidade relevada. Estabelecem-se bases teóricas que auxiliarão no desenho dos protocolos experimentais, na interpretação dos resultados e no estabelecimento das conclusões gerais da dissertação, mormente possibilitando um melhor enquadramento das potencialidades e limitações dos estudos empíricos.

No segundo artigo de revisão, sintetiza-se o estado da arte em torno dos paradigmas de investigação referenciais no estudo sobre a TD em desporto, os quais constituem a base de referência teórica e metodológica dos estudos empíricos realizados. Os principais métodos para a investigação nesta área são analisados, com um foco centrado no registo de movimentos oculares e na utilização dos relatos verbais, relacionados com um dos parâmetros focados no artigo precedente: a atenção. Por fim, procede-se a uma análise crítica dos desenhos experimentais e suas implicações para a análise dos resultados obtidos nos estudos empíricos, sobressaindo a pertinência de elaborar desenhos experimentais representativos das tarefas de performance para as quais se pretende generalizar os resultados.

O capítulo III integra os três artigos empíricos conduzidos durante esta investigação, todos eles conjugando dados de registo de movimentos oculares e relatos verbais. O primeiro dos artigos explora os mecanismos subjacentes aos processos perceptivo-decisionais numa tarefa complexa e representativa em voleibol, procurando discernir as diferenças entre peritos e não-peritos num contexto laboratorial de visualização de projeções de vídeo. Quinze atletas de voleibol feminino (nove peritas e seis não-peritas) realizaram uma simulação de tarefa defensiva perante cenários de construção de jogadas de ataque em situação de jogo formal (6 x 6). Combinou-se o registo de seguimento dos movimentos oculares com a recolha de relatos verbais retrospectivos imediatos para obter medidas do processo de TD. O estudo analisa os resultados obtidos, discutindo-os em função do nível de perícia das jogadoras.

O segundo artigo aplica a metodologia adotada no estudo precedente a um contexto *in situ*, potenciando a representatividade da tarefa ao aproximá-la do contexto real de prática. Vinte e sete jogadoras de voleibol (quinze peritas e doze não peritas) realizaram uma tarefa defensiva em contexto de jogo 6x6, durante a qual foram recolhidos dados relativos ao seu comportamento ocular e relatos verbais retrospectivos imediatos. O presente estudo amplia as considerações relativas às diferenças nos processos subjacentes à TD entre peritas e não-peritas, mas desta vez *in situ*, procurando fornecer dados mais relevantes para a prática e expondo as limitações que os métodos utilizados ainda apresentam quando aplicados num contexto de terreno.

Finalmente, o terceiro artigo empírico procura ir mais além, recorrendo a uma amostra única para comparar diretamente os processos perceptivo-decisionais em condições de projeção de vídeo e *in situ*. Nove jogadoras de voleibol de nível semelhante de perícia realizaram uma tarefa defensiva simulada perante observação de cenários de jogo 6x6 projetados em vídeo, bem como uma tarefa defensiva *in situ* em situação de jogo 6x6, comparando-se cenários semelhantes. De modo similar aos outros dois estudos, foram recolhidos, em cada condição experimental, relatos verbais retrospectivos imediatos e dados de seguimento ocular. Exploraram-se as diferenças relacionadas com a condição experimental (vídeo versus *in situ*) e discutiram-

se as suas implicações para a investigação, nomeadamente para a construção de desenhos experimentais.

O capítulo IV procura dar corpo e significado aos principais resultados obtidos na presente dissertação, sintetizando os conhecimentos mais relevantes e apontando futuros problemas e caminhos de investigação.

A Tabela 1 apresenta um quadro sinótico dos estudos realizados na presente dissertação.

Tabela 1 – Quadro sinótico dos estudos realizados na presente dissertação

Capítulo II	Ensaio teórico
Estudo 1	'Decision-making in sports: The role of attention, anticipation and memory' Publicado: Brazilian Journal of Kinanthropometry and Human Development, 2012, 14 (5), 592-601 Afonso, J.; Garganta, J.; Mesquita, I.
Estudo 2	'Investigação em perícia decisional em jogos desportivos: Paradigmas, métodos e desenhos experimentais' Aceite para publicação: Revista Portuguesa de Ciências do Desporto Afonso, J.; Garganta, J.; Williams, A.M.; Mesquita, I.
Capítulo III	Estudos empíricos
Estudo 3	'Skill-based differences in visual search behaviors and verbal reports in a representative film-based task in volleyball' Submetido: Research Quarterly for Exercise and Sport Afonso, J.; Mesquita, I.; Garganta, J.; McRobert, A.; Williams, A.M.
Estudo 4	'The perceptual cognitive processes underpinning skilled performance in volleyball: Evidence from eye-movements and verbal reports of thinking involving an in situ representative task' Publicado: Journal of Sports Science and Medicine, 2012, 11 (2), 339-345 Afonso, J.; Garganta, J.; McRobert, A.; Williams, A.M.; Mesquita, I.
Estudo 5	'Visual search behaviours and verbal reports of thinking during film-

	based and in situ representative tasks in volleyball' Aceite para publicação: European Journal of Sport Science, em Minor Revision Afonso, J.; Garganta, J.; McRobert, A.; Williams, A.M.; Mesquita, I.
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II. Ensaaios Teóricos

Decision-making in sports: The role of attention, anticipation and memory³

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Abstract – Expertise is a core goal for the achievement of elite-level performances. In sport, expertise is deeply related to the ability of making accurate decisions. In this context, decision-making becomes highly complex, due to a large number of relevant cues and interactions, as well as to multiple non-linear cause-and-effect relationships and severe time pressure. In this paper, three core components underlying decision-making were analyzed: attention, anticipation, and memory. They were explored within high-complexity contexts. The goals of this review were to: (i) provide a sound knowledge and contextual framing for the concepts of attention, anticipation, and memory in the context of decision-making in sports; and (ii) analyze how their effects vary according to situational constraints. Analysis of the literature allowed highlighting that, in sports, attention should be mainly goal-driven, selective, with external broadband focus. Anticipation, a tenet for attaining elite-level performances, is justified when it doesn't increase the rate of errors and is sensitive to counter-communication strategies applied by the opponents; therefore, certain contexts invite the players to adopt waiting strategies, especially when the risk taken by anticipation leads to a reduction in effectiveness. Memory provides a solid basis for attention and anticipation, and also originates and supports intuitive and strategic thinking. The knowledge obtained potentiates a better-calibrated perception of relevant variables for decision-making, therefore enhancing the contribution of scientific research towards practice.

Key words: Anticipation; Attention; Decision-making; Memory.

Resumo

A perícia é uma importante meta a alcançar na busca de elevadas performances. No caso dos jogos desportivos, a perícia está profundamente associada à capacidade de tomar decisões. Neste contexto, a decisão assume contornos de elevada complexidade, derivada dum conjunto alargado de indicadores e de interações a atender, às múltiplas e não-lineares relações entre ação e efeito, e à pressão temporal envolvente. Neste artigo,

investigaram-se três componentes nucleares subjacentes à tomada de decisões: a atenção, a antecipação e a memória. Percorreram-se as suas características em contextos de alta complexidade e de forte imponderabilidade. Os objetivos do presente artigo consistiram em: (i) aprofundar e contextualizar os conceitos de atenção, antecipação e memória no âmbito da tomada de decisão nos jogos desportivos; e (ii) analisar se os efeitos destas componentes dependerão de constrangimentos situacionais. Da revisão de literatura efetuada, salienta-se que, nos jogos desportivos, a atenção deverá ser essencialmente guiada por objetivos, seletiva, de foco externo e banda larga. A antecipação, potenciadora de elevadas performances desportivas, justifica-se no caso de não aumentar exageradamente a taxa de erros cometidos e é sensível a estratégias de contra-comunicação dos oponentes, pelo que determinados contextos convidam à adoção de estratégias de espera, nomeadamente quando o risco assumido pela antecipação se traduz numa redução da eficácia. A memória, informando quer a atenção, quer a antecipação, origina e suporta o pensamento intuitivo e alicerça o pensamento estratégico. Os conhecimentos obtidos permitem uma melhor perceção calibrada das variáveis especificadoras, potenciando os contributos da investigação científica para a prática.

Palavras-chave: Antecipação; Atenção; Memória; Tomada de decisão.

Introduction

Experts represent a select group of people who stand out from their peers for the excellence with which they achieve high-level results. This expertise is closely associated with the ability to make decisions¹, an intricate process that occurs in complex situations and under high time pressure². Since expert decision-making is a core component in the achievement of high performances in sports³, it is relevant and useful to ask which factors contribute the most to proficient decision-making.

The ability to make effective decisions seems to depend on a suitable orientation of the decider towards relevant indicators. This happens through the

attunement to the affordances of the environment, which are ‘invitations’ to action, a functional concept of action possibilities that relates the environments’ characteristics with the abilities of the individual⁴. To this end, individuals use attention, which is considered the best predictor of sports performance⁵. In fact, experts are better at catching early relevant indicators of the specific task⁶, using their attention abilities to better anticipate the outcomes of their own actions and the actions of opponents. However, anticipation is a phenomenon that has both advantages and disadvantages, emerging as beneficial in certain contexts, but detrimental in others⁷.

In this sense, the action of directing attention and predicting when the adoption of an anticipation strategy will be positive is embedded in a reference system that allows assessing the convenience of this decision: the memory⁸. The processes and manifestations of memory that influence the attentional and anticipatory processes may be multiple, ranging in depth and in the extent of its influence. The question becomes more complex if we invoke the concepts of *history of choices*⁹ – integrating multiple decisions in a coherent whole and resorting directly to strategic thinking – and *intuition*, as the culmination of potentiation processes developed through experience and learning¹⁰.

In particular, gaining expertise in sports games (SG) greatly depends on the ability to make decisions³ in circumstances of great imponderability. In this regard, the process of decision-making emerges from how attention⁵, anticipation⁷, and memory⁸ interact. The purposes of the present paper were: (i) to deepen and contextualize the concepts of attention, anticipation and memory in the context of decision-making in sports games; and (ii) to analyze if the effects of these components depend on situational constraints.

Development

The role of attention in decision-making

The control of attention can be mainly goal-driven or stimuli-driven¹¹. Most sensory receptors tend to adapt to continuous and regular stimuli, becoming, therefore, less sensitive to them, but simultaneously allocating more attention to new and unexpected stimuli¹². Thus, the ongoing actions may be corrupted by

the perception of new and relevant information sets¹³. The downside consists in the possibility of performance impairment, when the allocation of attention is directed to irrelevant indicators and/or distractors. Thus, in sports, it is important that players be able to make use of a strongly goal-driven¹⁴ attentional control, becoming less exposed to distractors, though still maintaining some room for the detection of unexpected but relevant indicators.

Once this premise is observed, the *style* of attentional control may vary. Attention may be selective – focused on a specific aspect – or divided – distributed in several tasks concurrently. When information overload is excessive, selective attention guides the limited perceptive resources towards the most relevant set of information¹¹, limiting the number of indicators to be processed by working memory in each moment. The working memory allows a limited amount of information to be kept in a readily accessible state, for rapid ‘consultation’¹⁵. However, information about the emotional and cognitive domains is available on a pre-attention form, and may highly interfere with attention allocation^{16,17}.

Moreover, attentional focus may be external or internal. An external focus results in decreased brain activity, implying a simpler and more automatic action⁷. By contrast, the internal attention foci tend to be associated with impaired performance, although this effect may depend on the complexity of the task¹⁸. Less complex tasks and tasks in which the context calls less to decision making, lead to a greater internal focus, a greater concentration on aspects related to the performance of the movements per se. The priority use of an external attention focus is beneficial in sports, and this focus may be restricted to a specific region of space (narrow band), with high resolving power, or spread over a broader region (broad band), but with less power resolution¹⁹. In SG, most emerging situations promote the maintenance of an external attention focus¹⁷, because the game is a source of unpredictability and uncertainty, requiring the maintenance of alert states for a diverse set of indicators⁴. Furthermore, broadband attention, which is more diffuse, stimulates the obtaining of information in a more global way, and thus, gives it greater meaning²⁰.

In short, attentional control, be it goal-driven or stimuli-driven, selected or divided, of internal or external focus, broadband or short band, is the responsible for enhancing or inhibiting the achievement of high performances. By directing attention to relevant indicators, athletes can use the collected information, allowing the anticipation of the unfolding scenario, which, consequently, is reflected in a performance more suited to the constraints of the task.

Anticipation – concepts, capabilities and limitations

There is a strong relationship between the accuracy of decision-making and the time required to performed it^{9,21}, a relevant relationship in sports, because a great degree of precision is required, but with an adequate answer speed²². What happens is that in sports uncertainty permeates decision-making, and the decisions have to be made even in the absence of complete information²³. Theoretically, performance in sports, particularly in SG, would benefit from the use of anticipation strategies, especially, in very fast paced situations². The adoption of such strategies is possible when there is an adequate guidance towards the relevant indicators, providing the athlete with certain information that arises relatively early in the scenario and that, via probabilistic relationships, allow to predict the outcome of the action⁶.

However, anticipation is far from being a simple phenomenon, as it may be useful and productive in some scenarios but harmful in others². In a study performed with soccer goalkeepers, exposed to video scenarios in real size, Savelsbergh et al.²⁴ verified that the individuals most likely to adopt an anticipation behavior, beginning their actions earlier, obtained worse success rates in accuracy and adequacy of their motor responses. Inversely, the most successful goalkeepers were those who waited longer, obtaining more information from involvement. Therefore, in this case, an overly early anticipation will tend to be harmful to performance. This study was developed in the laboratory and was based on their performance on a film-based test, but the question is even more complex in contexts of real practice, since a prolonged wait, even though it may allow collecting more information and thus increasing

the success rate of the response *intention*, it can also make the actual response ineffective, for not allowing the motor action to be produced in real time. That is, in a prolonged wait anticipation is accurate, but the action is late, and thus, unsuccessful.

From this it follows that the decision to choose between anticipation and waiting strategies depends on the specific situation, and it is necessary to weigh, in each case, the pros and cons²². Therefore, it seems that a faster, anticipatory decision only becomes advantageous if it does not result compromised by excessive errors⁷. Accordingly, because sports games are essentially tactical, they give this problematic even more complexity. By establishing a complex network of counter-communication in SG, certain game indicators may be created by the opponent in order to guide the opposing team in the wrong direction, creating false cues²⁵. In this context, estimates and anticipation may induce the player to choose the wrong path²⁶. To this extent, the cost-benefit correlation can, often, tip the scale in favor of strategies of waiting.

There are, however, situations in which time pressure is high, making the waiting strategies²⁷ unfeasible and calling for the adoption of anticipation strategies. For these reasons, anticipation, generally considered a mark of experts, should be addressed on the basis of the specific tasks and contexts, always after an assessment of their advantages and disadvantages⁹. Such analysis will depend, therefore, on a good knowledge of the situational probabilities, which allows to better define the scope of the analysis and to increase the speed and precision of decision-making²⁸.

The mediating role of memory in attention and anticipation

The direction of attention and adoption of strategies to anticipate depend largely on the memory. The ability to compare new data with data previously stored in the memory shapes progressively more sophisticated⁸ knowledge structures, fostering a better ability to make decisions. A better organization of information, by grouping it in units or coherent sets, full of functional meaning, speeds the process of relevant information recovery from memory, through a

more efficient mental search²⁹. However, some misconceptions seem to persist on the nature of memory and the way it operates.

Memory is a complex, multifaceted and reconstructive process³⁰. Thus, the concept of active and continuous processing should be emphasized, as opposed to a more static, concept of storage²⁹. Indeed, memory can be conceptualized as a ubiquitous energy field, conditioning responses to the multiple stimuli to which individuals are sensitive, shaping mental activity at each instant¹². Due to synaptic plasticity, mental representations become dynamic maps, constantly reorganized and highly sensitive to experience and to learning³¹. Thus, progress in motor skills and decision-making produce substantive changes in long-term memory³².

Although long-term memory is determinant to an effective higher ability to make decisions, it is insufficient. In fact, if the relevant information is kept only in long-term memory, it can be of reduced use for an effective understanding in a given situation. For decisions to be informed by memory, some relevant aspects should be adjoining the situation of decision-making, immediately available in working memory³³. However, this type of memory is limited to a few items, regardless of the complexity of the task¹⁵, requiring a careful selection of the most relevant information¹⁶.

Research has demonstrated that working memory has the same physical limitations, both in experts and novices, and it seems that long-term memory is the one that allows distinguishing experts from non-experts³⁴. However, this effect emerges only in the specific tasks of a given domain³⁵. Indeed, in random or non-specific scenarios, experts did not show better data recovery from long-term memory than novices³⁶. Thus we may infer that, to enhance memory advantages, players must be properly attuned to the task-relevant constraints³⁴. For working memory to be functional, it should be correctly guided by long-term memory, for this is the orientation that allows to carefully selecting the most relevant information to be available in working memory¹⁶.

From the above, it should be pointed out that memory is a process that encompasses a continuum of manifestations, interacting with decision-making in a dynamic and flexible way, exerting a strong modulation, an almost total

constraint, or even an irrelevant role in decision. In this regard, it is possible to distinguish two kinds of information processing²³: a) top-down, highly influenced by memory, purposes, expectations and specific knowledge of the situation; b) bottom-up, more related with the detection of novelty, with the unexpected. Both kinds of information processing are relevant in the context of SG: top-down processing informs the action based on the historic of the player, while bottom-up processing maintains the athlete open to unexpected emergencies. From memory emerges, also, intuitive thinking¹⁰, which shapes embodied knowledge, and strategic thinking³⁷, and translates the time sequences of the coherent decisions.

Regarding strategic thinking, it is known that a decision should be placed in its historic context. In eminently tactical sports, knowledge of the past and present situations interferes with every decision made³⁷, so that the decisional process is continuous and not disconnected⁹. As such, the present actions will constrain the possibilities afforded to future actions¹⁴, in some extent. In this context, it is introduced the possibility of using strategies of the style, ‘lose now, win later’³. Therefore, it is important to distinguish between a purely tactical decision and a strategic decision, since the latter implies a deeper planning and an interconnection of the various decision-makings undertaken at different moments³⁸.

Memory can also be characterized by its explicit or declarative, and implicit or procedural facets³⁹. Although the explicit component – the one we are aware of – is important, the implicit component may be more relevant in sports. With the accumulation of experience, some learning is embedded in the neuronal connections, meaning that, although people may not be aware of these memories, their body will respond accordingly. This phenomenon, called priming or potentiation, operates unconsciously, but greatly affects behavior^{10,22}. Taking this into account, we must be cautious in how to approach the concept of intuition in the decision-making process.

In everyday life, many decisions are guided by clearly unconscious reasons, especially in environments that place heavy time pressures, among which sports are included¹⁰. In these contexts, constraints induce a more

intuitive, more heuristic strategy of problem solving²¹. Indeed, when rational thought is taken to the extreme, performance tends to be impaired, a phenomenon called paralysis induced by analysis. However, intuition still tends to be faced as a somewhat mystical process, associated to the famous *eureka* of Archimedes. However, intuitive thought is filled with rationality, albeit to a sub-conscious level, precisely owed to the implicit learning processes that are incorporated and developed throughout life and learning¹⁰.

In fact, the practice and learning form consistent interconnections between perceptions and actions; then, the courses of action are enhanced by certain perceptions, causing the possibility of actions to be activated without emerging to consciousness^{10,23}. A negative aspect of this process of potentiation is its high dependence on a proper adjustment of the association between condition-action; when these associations are inappropriate or inaccurate, there is a high probability of actions to be inappropriate and, therefore, ineffective. Not even experts are immune to this negative effect of potentiation, with regard to intuitive-thinking⁴⁰. This implies that the quality and design of the preparation process decisively influence the implicit memory, and consequently, the intuitive process. To do so in a positive direction for performances, they will need to recreate specific and relevant condition-action adjustments.

Final comments

In eminently tactical sports such as SG, attention benefits from a strong goal-driven control¹⁴, though allowing some space for the stimuli-driven control. This commitment allows the execution of tactically aware actions, but permeable to the detection of unexpected elements in engagement. Due to the information overload usually present, selective attention tends to enhance performance¹¹, reducing the amount of potential indicators to be considered in decision-making. On the other hand, an external focus tends to benefit performance, by enabling better attunement to the constraints of the task and to the involvement, a nuclear aspect in SG¹⁷.

Due to a swift action based on incomplete information, individuals have to make a commitment between response speed and its adequacy²¹. In this

context, anticipation emerges as a way to produce a rapid and adequate answer to the demands of the situation. In SG, anticipation can be a powerful booster of high standard performances, but only if it does not drastically increase the rate of errors⁷ and if it is not eluded by strategies of ‘deception’ drawn up by opponents²⁶. Therefore, although anticipation usually has a positive connotation, in some circumstances, waiting strategies may be more beneficial.

In order to know how to direct attention and anticipate the results of actions, individuals need a support structure to inform these two components (attention and anticipation): memory⁸, which is an active, reconstructive and diffuse process, highly sensitive to learning³⁰, informing how we should or could run our actions. Concisely, it is the memory that embodies the knowledge of situational probabilities and, thus, enables the emergence of attention and anticipation. Because of its high specificity, the potentiating effect of memory is revealed only in specific tasks of a given domain³⁵. From memory emerge, still, intuitive¹⁰ and strategic thinking³⁷. The first embodies internalized knowledge, which become implicit; the second links each decision taken into a coherent whole. As such, it seems correct to defend a practice heavily based on the specificity of the requests, only then enabling the stimulation of attention and anticipation in a realistic and flexible manner.

In short, it should be emphasized that the triad attention-anticipation-memory helps the understanding of the factors underlying decision-making in sports, particularly in the search for variable specifiers, determinants of success in tactical action. The attunement to the variable specifiers of the situation is what allows a correct perception of the affordances of the system¹⁴. In this sense, knowing the specifier variables in their multiple and complex manifestations allows us to enhance the tuning affordances, influencing not only programs of practice development, but also the experimental designs used in scientific research.

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Investigação em perícia decisional em jogos desportivos: paradigmas, métodos e desenhos experimentais⁴

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Resumo

A excelência desportiva tem sido alvo de aturada pesquisa em ciências do desporto, sendo que, nos jogos desportivos (JD), tem evidenciado ser fortemente influenciada por marcadores do foro perceptivo-decisional. Neste artigo, pretende-se realizar uma sinopse em torno dos paradigmas de investigação de referência sobre a tomada de decisão, no contexto dos JD, calcorreando de seguida os métodos e, por fim, alcançando os desenhos experimentais mais utilizados. Os paradigmas da psicologia cognitiva e ecológica são contrastados e os seus contributos e limitações realçados. Os métodos mais comuns são esmiuçados, mormente o registo de movimentos oculares, pelo contributo que fornecem ao nível da informação relativa à visão central, e os relatos verbais, pela possibilidade de se aceder aos processos de pensamento e fontes de informação adicionais. Ao nível dos desenhos experimentais enfatiza-se a complexidade e a especificidade das tarefas, porquanto apenas considerando estas dimensões é possível alcançar um conhecimento autêntico e profundo sobre a problemática. Em jeito de síntese, este artigo enfatiza a premência da investigação no âmbito da perícia perceptivo-decisional nos JD contemplar uma multiplicidade de abordagens e métodos, pressupondo um maior grau de tolerância discursiva, de forma a intentar uma compreensão mais holística e ecológica dos fenómenos em estudo.

Palavras-chave: perícia decisional, jogos desportivos, performance

Abstract

Expertise in sports has been widely scrutinized by researchers in sports sciences. In team sports, expertise is strongly influenced by perceptive-decisional markers. In the present review, it is our intention to sketch a framework supporting the main research paradigms, methods and experimental designs around decision-making in sports. The cognitive and ecologic psychology paradigms are contrasted and their contributions and limitations are highlighted. The most commonly applied methods are examined in detail,

namely the recording of eye movements, due to their contribution with regard to information pertaining to the foveal vision, and the collection of verbal reports of thinking, as they provide a window into thought processes and additional sources of information. With respect to experimental designs, task specificity and complexity are approached, as these dimensions are crucial to attain a thorough and authentic knowledge of how experts make decisions in ecologic contexts. In sum, this review emphasizes the need for research in perceptive-decisional expertise in team sports to contemplate a manifold of approaches and methods, assuming a great degree of respect for a tolerant speech, with the purpose of attempting a more holistic and ecologic understanding of the phenomena under investigation.

Keywords: decisional expertise, team sports, performance

Introdução

A pesquisa científica no desporto tem devotado uma considerável atenção ao problema de como melhorar a performance de atletas e de equipas. Neste âmbito, uma das principais vias de investigação relaciona-se com a performance dos praticantes de excelência, ou peritos⁵, nomeadamente visando o que caracteriza a performance de qualidade superior, bem como os caminhos que conduzem à mesma. Apesar da enorme complexidade envolvendo esta temática, os investigadores têm vindo a abrir caminho e um alargado corpo de pesquisa tem providenciado um conhecimento consistente acerca destas matérias. Williams e Ericsson (87) propuseram a *expert performance approach* como um quadro de referência privilegiado para identificar performances de elevado nível e para compreender os mecanismos que lhes estão subjacentes. Os autores propõem uma abordagem em três passos: a) determinar o que discrimina os peritos dos não peritos, com auxílio

⁵ Ao mais alto nível de performance, os peritos representam um grupo seletivo de pessoas que se destacam dos seus pares, realizando sistematicamente performances de elevado nível, fazendo-o com fluidez e aparente naturalidade (19; 80).

de análise de vídeo e filme, análise notacional e simulações; b) investigar os processos subjacentes, através de métodos de seguimento de movimentos oculares, estabelecimento de perfis biomecânicos e relatos verbais; e c) examinar o desenvolvimento da perícia ou expertise, usando perfis de historial de prática desportiva e estudos de aprendizagem recorrendo a programas de intervenção prática.

O conceito de perícia é multifacetado e, de acordo com Janelle e Hillman (43), pode ser dividido em quatro grandes componentes: fisiológico, técnico, cognitivo (estratégico-tático e perceptivo-decisional) e emocional. Apesar de nem todos os peritos serem excecionais quanto à respetiva habilidade para tomar decisões (78; 87), nos jogos desportivos (JD) a habilidade de rapidamente tomar decisões ajustadas e precisas afigura-se essencial para aceder a elevadas performances (31; 36). A capacidade de lidar, com sucesso com tais exigências emerge como uma das principais características da perícia em JD (21; 87). Neste contexto, a perícia perceptiva e decisional denota ser uma componente nuclear do desempenho de excelência nos JD.

No presente artigo, são recompiladas, inicialmente, questões relevantes que envolvem o conceito de perícia, com particular ênfase na perícia decisional. Seguidamente, são abordados os principais paradigmas sobre a tomada de decisão (TD) – o cognitivo e o ecológico –, buscando não apenas compreender as concernentes implicações para a pesquisa, mas procurando também estabelecer pontes entre as duas conceções. De facto, a complementaridade dos dois paradigmas permite uma compreensão mais profunda da TD em processos da vida ‘real’, tendo em conta que alguns cenários poderão apelar a um acoplamento percepção-ação quase direto, enquanto que outros proporcionam relações mais complexas e indiretas entre percepção e ação. Posteriormente, o foco da abordagem desta revisão será direcionado para os métodos mais utilizados neste tipo de investigação, nomeadamente o seguimento dos movimentos oculares e a recolha de relatos verbais. O registo de movimentos oculares proporciona dados de interesse relativamente à visão central, que está profundamente relacionada com a alocação da atenção. Contudo, estes métodos ignoram *inputs* da visão

periférica, bem como de outras fontes sensoriais (e.g., audição, tato, propriocepção). Neste sentido, os relatos verbais podem assumir-se como complementares, proporcionando dados relevantes relativos aos pensamentos dos praticantes. Raramente a investigação tem combinado estes dois métodos num experimento (60), limitando o nosso entendimento dos processos decisoriais no desporto. Finalmente, serão abordadas questões respeitantes aos desenhos experimentais mais recorrentemente utilizados e às suas implicações para a análise dos dados. No âmbito desta problemática, é direcionada particular atenção para a especificidade da tarefa e sua complexidade, uma vez que os peritos são conhecidos por serem superiores aos não peritos apenas sob constrangimentos específicos da tarefa, não se verificando essa superioridade em tarefas fora do âmbito do seu campo de perícia. Neste sentido, espera-se contribuir para a sistematização do conhecimento a propósito da pesquisa no âmbito da TD em contextos desportivos e, paralelamente, sugere-se algumas estratégias que possam ajudar a balizar futuras pesquisas.

O desafio do conceito de perícia no desporto

A perícia relaciona-se com o alcançar repetido e sistemático de performances de elite, mesmo sob circunstâncias difíceis (23). Embora tal possa não ser totalmente verdadeiro em áreas nas quais um evento criativo assuma uma importância capital – por exemplo, criar uma obra de arte genial ou produzir uma descoberta científica fundamental –, é definitivamente este o caso no desporto (25). A perícia é específica para cada desporto (54) e, dentro deste, é específica para cada função e para cada tarefa (48; 93).

Não obstante, no desporto, a quantidade de experiência, reputação ou mestria de habilidades serem tomadas como medida da perícia, a investigação tem claramente demonstrado que existe apenas uma fraca correlação entre estes indicadores e a performance (13; 20). Acresce que a classificação dos peritos tem sido largamente arbitrária, variando de atletas Olímpicos até campeões de Desporto Escolar, enquanto os novatos vão desde jogadores com poucos anos de prática até indivíduos sem qualquer experiência prévia na

tarefa (86; 88). Consequentemente, alguns supostos novatos podem obter melhores performances do que alguns jogadores mais experientes (23). Adicionalmente, verifica-se que a definição de perícia evolui e muda com a idade, contexto e mudanças desenvolvimentais inerentes ao atleta (29). Nomeadamente, o papel desempenhado pelo contexto é de particular importância, uma vez que o jogador pode ser considerado perito numa equipa, mas apenas mediano quando jogando numa outra equipa (77).

Uma outra questão consiste em saber se a idade deve ser um fator a ponderar quando se aborda a temática da perícia. Embora a perícia tática pareça ser independente da idade cronológica dos sujeitos (29; 30; 38; 54), os peritos adultos são reconhecidamente melhores do que os peritos mais jovens na elaboração de perfis das características dos adversários e na monitorização do fluxo de jogo, bem como nos comportamentos antecipatórios (27). Acresce que as estruturas de conhecimento acompanham as melhorias no nível de habilidade e na complexidade do jogo, motivo pelo qual a idade pode converter-se num fator relevante (28). Adicionalmente, embora a função visual e seu *hardware* não melhore com o nível de perícia (41), melhora com a idade (92). Com efeito, uma idade superior é acompanhada por uma melhoria na discriminação intra-sensorial, conferindo maior qualidade à informação capturada pelo sujeito (30). Contudo, independentemente da idade, os novatos exibem um reduzido conhecimento específico da tarefa, atendendo apenas a informação tática superficial e estabelecendo planos de ação rudimentares (54). Mesmo em praticantes de apenas nove anos de idade, é possível distinguir diferentes níveis de perícia decisional (84).

Pelo referido, percebe-se que, embora o nível de perícia discrimine melhor as habilidades de TD do que a idade (28), os estudos sobre perícia deveriam considerar a interação da idade com o nível de perícia (84). Por outro lado, a perícia deverá ser entendida como um continuum de performance, isto é, não como uma categoria qualitativamente distinta, mas enquanto uma gradação que se estende de novato a perito (77).

Paradigmas de investigação em tomada de decisão em Jogos Desportivos

Paradigma cognitivo: conceitos e limitações

De acordo com as teorias cognitivas, a TD em desporto coletivos ocorre em três etapas (51): a) percepção e análise da situação; b) elaboração duma solução mental; e c) execução duma resposta motora. Implicada neste processo está a necessidade de tomar *duas* decisões em cada sequência de ação: uma respeitante ao *que fazer*, outro ao *como fazer* (35). Todavia, uma vez que o processamento de informação tem capacidade limitada, tais modelos puramente cognitivos encontram limitações severas quando se trata de interpretar e explicar a habilidade para tomar decisões em situações complexas que ocorrem em curtos lapsos de tempo. Um procedimento que permite minorar este efeito é o agrupamento ou *chunking* de blocos de informação em conjuntos ou padrões significantes, mecanismo pelo qual a carga informacional pode ser reduzida (54). Este processo alivia a carga informacional tanto pela redução do número de elementos a analisar e processar (69; 74; 86), quanto pelo seu maior impacto na memória, uma vez que situações plenas de significado tendem a ser mais facilmente memorizadas (54; 83).

Além disso, avanços na psicologia cognitiva consideram que as redes neuronais cerebrais utilizam duas vias complementares e simultâneas de processamento de informação: a) uma via em série, de baixo custo, aplicável eficazmente quando existe algum tempo disponível para tomar uma decisão; e b) uma via paralela, mais intuitiva e subconsciente, capaz de lidar, em especial, com severos constrangimentos temporais (86). As duas vias são igualmente importantes, uma vez que o desporto combina situações que exigem reações rápidas com outras que possibilitam um maior grau de reflexão (45).

Apesar da inegável utilidade dos modelos cognitivos, diversas críticas têm-lhes sido dirigidas. De acordo com Abernethy, Farrow e Berry (2), este paradigma tem uma validade limitada no desporto, devido aos severos constrangimentos temporais e à elevada complexidade espacial e multiplicidade de interações, mesmo considerando o papel do processamento paralelo. Adicionalmente, a perspetiva cognitiva baseia-se na separação

Cartesiana entre mente e corpo (37), bem como numa visão computacional da mente (67). Tal implica a necessidade de criar representações internas da informação e sua interpretação, um procedimento inviável em muitas ações rápidas, como aquelas que tipificam os JD (11; 86). Acresce que, como afirma Capra (14), o pensamento racional puro é um sistema de conceitos abstratos com uma estrutura linear, claramente em contradição com a multidimensionalidade e não-linearidade da maior parte das atividades humanas. À luz destas críticas, têm vindo a ser desenvolvidas perspetivas alternativas, grande parte das quais se filia na psicologia ecológica.

Paradigma ecológico: conceitos e limitações

No desporto, a maioria das decisões são tomadas no decurso da ação (5), e, no caso dos JD, estando atleta e objeto de jogo em movimento (86). É conhecido que o movimento, em si mesmo, gera informação e potencialidades de ação, de tal modo que a perceção gera movimento, estabelecendo a base para as teorias do acoplamento perceção-ação (34; 86). Esta ligação bidirecional entre perceção e ação foi demonstrada nos estudos de Slobounov et al. (75) e Stoffregen et al. (76). Trata-se de uma relação complexa de mútua dependência e causalidade circular entre sistemas percetivos e sistemas de movimento (37; 67), no seio da qual emerge a tomada de decisão (5; 90), a qual se vai alterando no decurso da ação (83). Estes acoplamentos perceção-ação são específicos para cada contexto (66) e remetem para outro conceito nuclear no âmbito das teorias ecológicas – a noção de constrangimento.

Os constrangimentos constituem restrições à ação, cujas interações provocam a emergência de ações coordenadas (4; 5). Na ausência de constrangimentos, os graus de liberdade para a ação tornar-se-iam infinitos, perdendo o sistema a capacidade de se auto-organizar (86). Três tipos de constrangimentos são comumente identificados: organizmicos, envolvimentais e de tarefa (37). A título de exemplo, a altura de um indivíduo é um tipo de constrangimento do organismo; as condições de temperatura são constrangimentos do envolvimento; e a situação de jogo em cada jogada ou *rally* são típicos constrangimentos da tarefa. Para lá desta divisão, Beek et al.

(7) distinguem duas classes de constrangimentos: a) constrangimentos globais, que são invariantes por natureza; e b) constrangimentos locais, que variam, mas usualmente não modificam a natureza dos constrangimentos globais.

A interação dos diversos constrangimentos induz ou inibe certas vias de expressão, emergindo as *affordances* como possibilidades ou oportunidades para a ação (34). O conceito de *affordance* é funcional, sendo um exemplo muito concreto oferecido por Williams et al. (86): uma bola em voo não é percebida em termos das suas dimensões, cores, densidade, distância ao alvo, nem qualquer outro atributo físico. Em vez disso, é percebida de acordo com as suas oportunidades para ação – que ações deve ou pode o atleta realizar numa dada situação. Considerando que as situações táticas, típicas dos JD, implicam movimento, e que este impõe mudanças contínuas no campo visual (83), as *affordances* assumem um carácter dinâmico (34). De acordo com a psicologia ecológica, apreender as *affordances* envolve uma sintonização com as relações funcionais entre o movimento e o contexto específico de performance (4; 66; 81).

Este processo é específico para cada indivíduo, no sentido em que varia na dependência de constrangimentos inerentes ao organismo (17; 50). Em resultado disso, as *affordances* assumem uma dupla natureza, tanto objetiva (i.e., elas existem na natureza) como subjetiva (i.e., apenas existem em relação a algo ou alguém) (6; 32; 34). Inclusivamente, o mesmo sujeito pode descobrir múltiplos significados ou possibilidades de ação partindo do mesmo conjunto de *affordances* (34). O significado de cada *affordance* e a sua perceção podem mesmo mudar à medida que a habilidade do sujeito e a sua competência para a ação evoluem (68). Assim, embora as *affordances* estejam presentes no envolvimento, o grau e modo pelos quais são percebidas são afetados pelas experiências específicas de cada sujeito (33; 83). A natureza evasiva das *affordances* deve, contudo, alertar-nos contra uma posição dogmática que desconsidere em absoluto o papel de representações internas mediando perceção e ação.

No alcance duma perspetiva integradora e complementar

Na discussão do fenómeno da TD, o meio-caminho pode constituir a abordagem mais contrabalançada e profícua. As teorias cognitivas concedem que a cognição é um fenómeno emergente pervasivamente embebido no nosso corpo – não apenas o cérebro, mas todo o complexo sistema nervoso-corpo – e no envolvimento (16; 27; 79). Por seu turno, investigadores do domínio da psicologia ecológica advogam que os sistemas biológicos podem, até certo grau, regular a forma como interagem com os constrangimentos e os manipulam, amplificando, por essa via, as possibilidades de ação (5). A interação dos constrangimentos estreita o número de graus de liberdade, mas geralmente não compele a uma opção única. Isto confere espaço para alguma deliberação consciente relativa às escolhas possíveis entre diversos cursos de ação. Independentemente do quadro de referência adotado, torna-se claro que a maioria das situações aceita uma ampla gama de soluções, todas contendo incerteza respetivamente ao resultado final. Mais ainda, é possível perceber algo e, apesar disso, escolher não atuar, na medida em que as ações tendem a emergir apenas quando certos limiares são ultrapassados (45).

Outra questão relevante nos JD referencia-se ao facto de as habilidades técnicas estarem profundamente relacionadas com a perceção (36), uma vez que as soluções mentais têm de ser traduzidas em soluções motoras (54). Assim, uma decisão torna-se apropriada quando é suscetível de ser aplicada, o que remete para a importância do conhecimento ou consciência dos recursos e limitações próprios (29; 35; 36). Acresce que as habilidades percetivas dos atletas melhoram à medida que melhoram as suas habilidades motoras (40). Com a melhora da habilidade motora, os jogadores tornam-se menos dependentes da informação visual, controlando alguns aspetos das suas ações graças ao controlo propriocetivo (26; 62). Concomitantemente, libertam a visão dum controlo técnico, internamente centrado, para um controlo tático, externamente centrada, evidenciando, inequivocamente, a relação existente entre a habilidade motora e a perícia decisional (77).

A complementaridade dos paradigmas ecológico e cognitivo permite elencar alguns indicadores que condicionam a TD: a) cada situação possibilita certas ações e a interação dos diferentes constrangimentos diminui o leque de

possibilidades de ação; *b*) cada jogador tem o seu próprio historial, experiência e representações mentais, que medeiam a interação dele com o envolvimento e a tarefa; *c*) dependendo das características de cada situação, o processo decisional poderá situar-se algures num continuum que vai de um processo totalmente auto-organizado e espontâneo até um processo estritamente deliberado e racional; *d*) as tomadas de decisão são sempre específicas da tarefa e do contexto.

Métodos na investigação em tomada de decisão nos Jogos Desportivos

Em qualquer campo de pesquisa científica, a investigação empírica requer o desenvolvimento e aplicação de certos métodos e ferramentas. Tal como o martelo pode ser uma ferramenta adequada para problemas envolvendo pregos, também determinados métodos e ferramentas são propensos a abrirem portas relacionadas com os processos decisoriais. Embora tenha sido desenvolvida ou adaptada uma pletora de métodos para aplicação no campo da TD em desporto, iremos focar-nos nos dois mais usualmente utilizados nesta área: o registo de movimentos oculares – como porta de acesso para os processos da visão central –, e a coleta de relatos verbais – oferecendo informações respetivas aos pensamentos que subjazem certos cursos de ação.

Registo de movimentos oculares

A TD no desporto depende fortemente do *input* visual (86). Todavia, está demonstrado que a qualidade da perceção não depende apenas, nem fundamentalmente, do *hardware*, mas de outros fatores (78; 92). A visão é, com efeito, um comportamento direcionado pela atenção (72), processo ativo envolvendo um curso pró-ativo de ação sobre o envolvimento que nos rodeia (16; 39). Consequentemente, uma ajustada alocação da atenção tende a preceder comportamentos motores eficazes (54; 90).

Por sua vez, a fixação ocular nas pistas relevantes tende a associar-se com a visão central ou foveal. A fóvea é especializada em discriminação fina, detalhes e visão a cores, cobrindo um campo visual de 2-3º (47). Por este

motivo, a análise da duração das fixações é usada como indicador da quantidade de informação processada (52; 87). Contudo, as estratégias de procura visual são mutáveis (11; 90), permitindo o seu melhor ajustamento aos constrangimentos singulares colocados por cada situação (52; 78).

Acresce que os comportamentos de busca visual se apoiam em diversos tipos de movimentos oculares. Os movimentos de *perseguição suave* seguem objetos ou alvos em movimento, mas têm uma velocidade máxima de apenas 100º por segundo, tornando-se inviável utilizá-los para manter o controlo visual dum objeto movido elevadas velocidades, o caso da bola nos JD (46; 83). Como tal, os movimentos oculares mais frequentes em contextos com elevados constrangimentos temporais são os *movimentos sacádicos*, movimentos rápidos que direcionam a fóvea para um novo ponto no espaço, podendo alcançar uma velocidade de 700º por segundo (9). As sacadas superam as limitações dos movimentos de perseguição suave, mas apresentam um senão: durante uma sacada, não há captura de informação visual, fenómeno designado de supressão sacádica (3). Teoricamente, fixações mais prolongadas e menores mudanças no local de fixação favorecerão a recolha de mais informação do envolvimento, devido a uma menor implicação da supressão sacádica (39; 63).

Finalmente, o *quiet eye* emerge como conceito nuclear na investigação relacionada com a TD. O *quiet eye* é a última fixação que precede a ação, num ângulo visual de 3º ou menos, por um período não inferior a 100 milissegundos, constituindo uma sólida medida da qualidade da coordenação percetivo-motora (83). Ao *quiet eye* é atribuído o controlo da atenção visual (8; 42). Quando este se inicia mais cedo e se prolonga por mais tempo, o efeito tende a gerar uma performance de qualidade superior, algo que vem sendo demonstrado em múltiplas modalidades desportivas e diversos contextos (8; 44; 52; 91). Não obstante, é primordial referir que um *quiet eye* demasiado prolongado pode prejudicar a performance (8; 83), especialmente em desportos cujo ritmo é externamente regulado (42), como no caso dos JD.

A investigação centrada na análise dos comportamentos visuais tem evidenciado que os peritos utilizam padrões de procura visual distintos dos não

peritos, e que os primeiros são mais económicos ou sintéticos do que os segundos. Os resultados sugerem que os peritos exibem uma menor frequência de fixações, mas com superior duração média por fixação e com maior economia do processo (82), como foi verificado numa meta-análise conduzida por Mann et al. (52). Não obstante, em desportos como os JD, pode emergir a necessidade de atender a diversas potenciais fontes de informação, pendendo a vantagem, nestes casos, para estratégias de busca visual que empreguem um maior número de fixações, mesmo com duração inferior (86). Desta forma, uma maior taxa de fixações pode constituir uma exigência dos constrangimentos da tarefa, sendo expectável que varie de acordo com o contexto e com o número de localizações contendo potenciais pistas relevantes (63).

As diferenças entre peritos e não peritos estendem-se, ainda, à natureza dos indicadores observados (71; 78). A natureza dos indicadores fixados pelos peritos diferem daqueles para os quais os não peritos deslocam a sua atenção, como vem sendo demonstrado em vários estudos (e.g. 69; 85). Investigação conduzida com jogadores de voleibol revelou que os peritos se focavam mais no braço do atacante, enquanto os novatos observavam mais a cabeça (64). No futebol, Roca et al. (70), demonstraram que os jogadores mais habilidosos gastaram significativamente mais tempo fixando áreas de espaço livre em comparação com os jogadores menos habilidosos. Portanto, os atletas peritos são capazes de melhor detetar os indicadores relevantes e capturar a informação mais substantiva (47; 90; 87).

Em suma, apesar dos comportamentos de busca visual serem importantes no estudo das relações entre perícia e TD, os mesmos não proporcionam uma compreensão cabal desta relação. Nomeadamente, a relação entre fixação visual e *locus* atencional não é linear (59; 78; 87). De facto, à medida que o nível de perícia aumenta, os praticantes dependem menos da visão central, uma vez que capturam mais informação a partir da visão periférica, bem como de fontes auditivas, táteis e propriocetivas (7; 50; 90). Portanto, emerge a necessidade das pesquisas considerarem outras

possibilidades, apelando a métodos de estudo complementares, tais como os relatos verbais (56; 61; 87).

Relatos verbais

As considerações prévias implicam o reconhecimento de que se torna conveniente que a pesquisa considere fontes complementares de informação acerca do fenómeno da TD. Neste sentido, os relatos verbais emergem como um poderoso utensílio suscetível de responder a tais preocupações, ao providenciar uma janela para os pensamentos dos jogadores. A partir das limitações da pesquisa baseada no seguimento de movimentos oculares, os relatos verbais têm sido propostos como uma via de acesso aos pensamentos dos praticantes, permitindo a identificação das fontes de informação subjacentes à TD (15; 56; 87). Tais procedimentos vêm sendo considerados como complementares aos protocolos de busca visual (61), ao permitirem o acesso à compreensão dos processos cognitivos mediadores da percepção-ação (87). Embora se questione até quanto os peritos são capazes de aceder conscientemente aos pensamentos subjacentes à sua performance (2), o facto é que a recolha de relatos verbais tem demonstrado ser um processo válido de aceder ao conhecimento processual (58).

A pesquisa com recurso a relatos verbais durante a resolução de problemas ou performance tem fornecido evidências de que elevados desempenhos estão associados a bases de conhecimento específicas dum dado domínio, e não a estratégias cognitivas gerais (56). Em resultado disto, as diferenças de performance relacionadas com a perícia são mais pronunciadas em tarefas específicas do seu domínio de intervenção (57). No âmbito deste quadro de referência, os relatos verbais retrospectivos têm sido utilizados para recolher informação acerca das estruturas de conhecimento que suportam a ação, bem como de processos de pensamento durante os eventos (56). De acordo com estes autores, os relatos verbais recolhidos durante a performance numa tarefa revelam que as representações do problema guiam a interpretação do *input* e a recuperação de informação relevante mobilizada através da memória de trabalho.

Desenhos representativos da tarefa

Independentemente dos métodos utilizados para recolher os dados necessários, os peritos revelam uma vantagem superior sobre os não peritos, quando as condições experimentais se aproximam das condições de prática e, portanto, são mais ecológicas (52; 53; 89). Além disso, os peritos têm respostas de reação motora significativamente mais rápidas do que os novatos (61; 86). Acrescenta-se ainda que as diferenças entre peritos e não peritos se ampliam consideravelmente sob a influência de constrangimentos de tarefa desafiantes e exigentes (20). Estes factos advertem para a necessidade da pesquisa, no âmbito da perícia, utilizar desenhos representativos da tarefa que se procura replicar, traduzindo desta forma as características essenciais da perícia num dado domínio (24).

Uma das preocupações centra-se, sem dúvida, na especificidade da tarefa. As estratégias de busca visual são específicas da tarefa (86) e, como tal, a estrutura e o significado funcional dos cenários tornam-se essenciais para despoletar a vantagem da memória específica do perito. Num estudo experimental, Shim et al. (73) colocaram tenistas numa tarefa *in situ* de receção ao serviço. Numa primeira situação, os jogadores recebiam serviços vindos dum oponente humano, enquanto que na segunda situação recebiam bolas enviadas por uma máquina de servir. Esta última, ao contrário dos adversários humanos, não fornece qualquer pista visual relativa à intenção ou à trajetória da bola. Como seria de esperar, o tempo médio de resposta aumentou na segunda situação. Nesta senda, Borgeaud & Abernethy (11) conduziram um estudo em voleibol, contrastando jogadores com não jogadores e considerando que, comparativamente aos não jogadores, os jogadores seriam peritos. Ficou demonstrado que os jogadores eram melhores a relembrarem as posições dos atletas nas situações de jogo, mas não quando se tratava de exercícios de aquecimento. Os efeitos da especificidade da tarefa sobre as estratégias de procura visual foram também demonstrados no âmbito do râguebi (66) e do futebol (78).

Assim, quando as tarefas experimentais não são específicas, especialmente quando apelam a distintas estratégias decisoriais, as performances ficam comprometidas (21; 22; 13), podendo mesmo os peritos apresentar resultados inferiores aos dos novatos (10; 82). Assim, tem sido consistentemente suportada a necessidade da pesquisa respeitar a especificidade das tarefas, incluindo uma necessidade de ação, e não apenas um requerimento de percepção sem necessidade de atuar (1). A pesquisa conduzida em contextos laboratoriais, nomeadamente usando projeção de slides ou de vídeo, tende a negligenciar o carácter contínuo dos estímulos, apresentando-os como entidades discretas, separadas, o que compromete, consequentemente o acoplamento percepção-ação (34; 86), devido à remoção do significado funcional da ligação estímulo-resposta (18). Tais limitações são particularmente evidentes em estudos que recorrem a imagens estáticas ou diapositivos, nos quais a apresentação de estímulos discretos e sem movimento introduzem, artificialmente, a latência ou tempo de reação, desconsiderando o controlo corrente da visão (49; 65). Considerando que os peritos são mais competentes a anteciparem ações, pode depreender-se que as técnicas de imagens estáticas limitarão a sua eventual superioridade (54), não capturando a sua performance efetiva. Para além disso, a apresentação de imagens estáticas fornece uma perspetiva não representativa do jogo, removendo importante informação contextual (11; 86). Desta forma, os vídeos podem oferecer algumas vantagens, mas, mesmo neste caso, a redução do tamanho da imagem e da sua dimensionalidade (bidimensional e não tridimensional) é propensa a afetar o processamento de informação (52).

Os estudos de *vision-in-action* proporcionam contextos mais realistas, nos quais os jogadores podem atender à evolução das sequências de jogo, fazendo uso de informação contextual e antecipatória, a partir de probabilidades situacionais (27; 83; 86). Os estudos que recorrem a este paradigma facilitam também a percepção de profundidade (90). A conjugação destes argumentos sugere que a pesquisa relativa às estratégias visuais no contexto da TD deverá evoluir no sentido do paradigma de *vision-in-action*, o qual respeita de modo mais profundo o acoplamento percepção-ação (83).

Porém, a tecnologia concebida para apurar o seguimento ocular não é ainda suficientemente refinada nem adequada para se ajustar satisfatoriamente a contextos desportivos dinâmicos (86). Além disso, mesmo na tradicional análise de vídeos ou diapositivos, algumas diferenças lógicas entre peritos e novatos emergem, nomeadamente a maior rapidez dos peritos ao responderem e um maior grau de precisão das suas respostas (48; 64). Portanto, embora se admita que apresentam limitações, estes métodos permanecem válidos e úteis na discriminação de níveis de perícia.

Sabendo-se que em condições experimentais altamente controladas e simplificadas, os peritos não revelam necessariamente melhores performances do que os novatos (19), a *complexidade da tarefa* deverá também ser objeto de atenção na condução de estudos empíricos (55). Com efeito, esta interfere com as estratégias de busca visual, induzindo diferentes taxas de procura e alterando os locais de fixação (78). Por outro lado, a complexidade da tarefa tende a ser linearmente acompanhada por um aumento na duração do *quiet eye*, na maioria dos sujeitos mais proficientes (91), acrescendo que os peritos lidam melhor com estímulos complexos (69). Por seu turno, o efeito da perícia, quando avaliado pela precisão da resposta, manifesta-se apenas, em última análise, nos níveis elevados de complexidade (28; 73). Não obstante estes efeitos evidentes da complexidade da tarefa na performance, esta não interfere automaticamente com o tempo de reação – especialmente quando não estão presentes elementos distrativos, ainda que a performance possa perder qualidade (12). Analogamente, é raro os peritos encontrarem os mesmos desafios sob condições semelhantes (25).

Estes considerandos justificam que o estudo da perícia decisional deve procurar simular, tão precisamente quanto possível, os contextos competitivos reais do desporto (27; 55), replicando a sua complexidade e pressão temporal (69).

Considerações finais

Constituiu propósito desta revisão sumariar questões nucleares que envolvem o estudo da perícia decisional nos JD. Pese embora a aparente

divergência entre os paradigmas cognitivo e ecológico, admite-se que ambos aportam contribuições fortes para a compreensão da TD em contextos de prática desportiva. Embora a percepção direta possa ser um facto em determinadas situações, a maioria dos cenários desportivos envolvem percepção indireta, onde o tempo e a complexidade induzem uma decisão mais imediata ou mais mediata. Independentemente do fator predominante, o conhecimento e a sintonização aos constrangimentos permitem aos jogadores explorarem eficazmente cada situação, diminuindo as suas opções para um número reduzido e exequível. Também é claro que as habilidades decisoriais dependem dos constrangimentos físicos e técnicos exibidos pelos jogadores. Finalmente, os processos envolvidos na TD são sempre específicos da tarefa e do contexto, algo que se deve refletir nos desenhos experimentais.

A visão constitui, talvez, a mais relevante fonte de informação no desporto. A investigação neste domínio tem revelado diferenças relacionadas com a perícia ou nível de habilidade na taxa de procura visual e nas localizações de fixação, bem como no *quiet eye*. Não obstante, a natureza destas diferenças varia de acordo com a modalidade praticada e com a natureza da tarefa apresentada. Tal explica a multiplicação e o desdobramento das pesquisas de acordo com a disciplina desportiva e a tarefa, e recomenda prudência quanto à extrapolação de resultados de um contexto para outro, bem como no que respeita à generalização dos mesmos. Mais ainda, os conhecimentos atinentes à visão central não são suficientes para se entender plenamente a forma como os jogadores fazem uso da informação disponível, para além de não considerarem informações que estão fora do domínio da visão central.

Neste contexto, os relatos verbais são encarados como uma via para os pensamentos dos praticantes, possibilitando o acesso a fontes de informação adicionais. Recentemente, começaram a figurar em estudos que os combinam com o seguimento ocular (60). Os relatos verbais proporcionam uma janela para os processos cognitivos mediando percepção e ação (87). Refira-se que as diferenças relacionadas com a perícia são mais pronunciadas em tarefas específicas dum dado domínio (56). No âmbito deste quadro de referência, os

relatos verbais retrospectivos têm sido utilizados para recolher informação acerca dos processos subjacentes à TD numa dada situação.

Como se pode constatar, independentemente dos paradigmas e métodos utilizados na pesquisa, a performance superior dos peritos parece emergir apenas sob condições específicas do seu domínio. Por isso, as tarefas experimentais deverão ser específicas. Entre as sugestões possíveis, a investigação deverá considerar seriamente o paradigma *vision-in-action* (83), preferencialmente em estudos de terreno. Neste âmbito, a complexidade da tarefa deverá aproximar-se, tanto quanto possível, das condições naturais. No entanto, limitações relativas ao tempo de investigação e a constrangimentos de índole tecnológica ainda forçam os investigadores a recorrerem a soluções que obstem a necessidade de ecologizar as avaliações.

Em suma, no sentido de se aceder a um conhecimento mais profundo, o caminho da investigação deverá apoiar-se numa multiplicidade de métodos e abordagens, fornecendo uma compreensão mais holística dos fenómenos estudados e um maior grau de tolerância discursiva; o campo da perícia percetivo-decisional não deverá constituir exceção. Neste contexto, a abordagem da perícia em contextos desportivos reclama uma pesquisa plural, combinando diferentes e complementares paradigmas e métodos e considerando, em particular, a complexidade e a especificidade das tarefas visadas.

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III. Estudos Empíricos

Skill-based differences in visual search behaviours and verbal reports in a representative film-based task in volleyball⁶

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Abstract

Purpose: A desire to increase understanding of the mechanisms underpinning expert performance has motivated a large body of research. We examined the processes supporting skilled performance in a complex film-based volleyball task using a representative simulated environment. *Method:* Participants were presented a complex, game-like volleyball task. We combined eye movement recording with immediate retrospective verbal reports of thinking in fifteen elite female volleyball players, ranked into skilled and less skilled groups. *Results:* Skilled players employed longer fixations than their less skilled counterparts, and spent a greater amount of time fixating the receiver and functional spaces between two or more players. Skilled participants generated significantly more condition concepts, and presented a superior level of sophistication in their verbal reports. *Conclusion:* data suggests that it is irrelevant to use tasks that simulate real-life environments. The definition of functional spaces, aiming for locations that stimulate retrieving information from more than one cue at a time, affords researches to use eye-tracking devices to analyze peripheral vision. The collection of verbal reports allows understanding if those functional spaces were indeed relevant for the subjects. Researchers need to be thoughtful when designing representative tasks in order to accurately simulate competitive contexts.

Keywords: perceptual expertise; gaze behavior; thought processes; test design

Perceptual and cognitive skills are assumed to be core concepts of performance in dynamic, time-constrained domains such as in sport (Dicks, Button & Davids, 2010), the military (Janelle & Hatfield, 2008), and even daily activities (Patla & Vickers, 2003). However, limited effort has been devoted to identifying the processes underpinning superior performance (McRobert, Williams, Ward & Eccles, 2009). It is acknowledged that experts adapt more rapidly to specific task constraints and anticipate the outcome of the action (Williams, Ford, Eccles & Ward, 2011), but the nature and magnitude of these

differences varies considerably depending on the type and complexity of the task (McRobert, Ward, Eccles & Williams, 2011), as well as the experimental design employed (Button, Dicks, Haines, Barker & Davids, 2011). The superiority of experts over non-experts is more pronounced as the complexity and specificity of the task is enhanced (Williams, Ward, Ward & Smeeton, 2008), but most experiments have used tasks that present smaller complexity than real-life events (e.g., Piras, Lobietti & Squatrito, 2010).

With regard to research methods, a number of researchers have examined the visual search behaviors used during performance when viewing film-based simulations of the performance context (Roca, Ford, McRobert & Williams, 2011). However, published reports suggest that the relationship between gaze and attention is not linear (Vaeyens, Lenoir, Williams, Mazyn & Philippaerts, 2007). In order to effectively capture the mechanisms supporting superior performance, it is necessary to use complementary methods, by for example, combining eye-movement registration with verbal reports of thinking (Ericsson & Williams, 2007). Visual search data provide an indication of how the visual system is used to extract information from the display, whereas verbal reports provide a measure of how the information extracted is translated into a decision. Thus far, research using eye-movement recording and verbal reports of thinking has followed almost parallel streams. The tendency has been to apply the two methods relatively independently, often in separate experiments (for an exception, see McRobert et al., 2011).

In the present study, we examined the processes underpinning skilled performance in a dynamic, externally paced complex volleyball task using a representative simulated environment while combining simultaneous eye movement recording and verbal reports of thinking. The task required defenders to analyze sequences of offensive moves. As the task presented highly complex, game-like scenarios, it was expected that its data was representative of the specific task constraints in volleyball. The combination of eye tracking data and verbal reports is expected to provide a more thorough understanding of the mechanisms behind decision-making in sports.

Methods

Participants

Fifteen elite female volleyball players were recruited. A panel of five expert coaches knowledgeable of the participants ranked them into skilled ($n=9$; 16.1 ± 2.0 years of age) and less skilled ($n=6$; 16.8 ± 2.0 years) age-matched groups based on a subjective evaluation of their decision-making skills, based on the procedures reported by Baker, Côté and Abernethy (2003). The inter-observer agreement percentages ranged from 80 to 86.7%. Participants signed an informed consent form and reported normal or corrected to normal levels of visual function. They were free to withdraw from testing at any stage. The study followed the lead institution's ethics guidelines.

Materials and apparatus

A simulated task environment was developed to assess participants' decision-making in volleyball. Participants were exposed to filmed sequences that were back-projected (Epson EMP-S3 3LCD Projector) onto a large screen (1.8 m height x 2 m wide). The film clips were played through QuickTime Player[®] (version 10.1), and the screen was placed 4 m directly in front of the participant. Participants were free to move, as they would do when playing in a match.

Twelve female (mean age 22.9 ± 4.7 years) volleyball players were recruited to create the test stimuli. A digital HD video camera (Sony Handycam HDR-XR550VE) was used to record the stimuli from a backcourt perspective at 60Hz. The camera was positioned at a slightly elevated perspective (approximately 3 m) near the endline of the serving team. The sequences included a serve towards the opposite side, after which six players would run an offensive sequence and three blockers tried to stop the attack. In total, six video trials were created. A panel of three expert volleyball coaches determined their content and structure. All trials were approximately 5 seconds in length each ending at the moment in which the ball crossed the block so as to standardize sequence duration. The filming was conducted on a standard size volleyball court. The test footage was collected over a 2-hour session and was later

digitally edited using Apple iMovie'09 to construct a number of short clips to be used in the simulation task. At the start of each clip, a black screen with a centered numbered countdown (3-2-1) appeared to prepare the participants.

Participants assumed a backcourt defensive position and had to follow attacking sequences from the opposing team. Visual search data were recorded using the Applied Science Laboratories 3000 MobileEye™ registration system (Bedford, MA, USA), which is a video-based, monocular corneal reflection system that records eye point-of-gaze with regard to a head-mounted color scene camera. The system measures the relative position of the pupil and corneal reflection in relation to each other through an infrared light source, using these features to compute point-of-gaze by superimposing a crosshair onto the scene image captured by the head-mounted camera optics. The image exhibits a sampling frequency of 30Hz (30 frames per second). System accuracy was $\pm 0.5^\circ$ visual angle, with a precision of 0.5° in both the horizontal and vertical fields. The video footage was analyzed frame-by-frame using Avidemux® 2.5.4. for Mac.

Verbal reports were recorded with a Sony ICD-UX70 digital audio recorder and copied to an Apple MacBook Pro (2.4GHz Intel Core 2 Duo), opened with VLC Media Player version 1.1.111 and copied to a datasheet on Microsoft Excel® 2008 for Mac. Before being tested, the players were given a thorough explanation on how to provide verbal reports (Araújo, Afonso & Mesquita, 2011).

Procedure

The MobileEye™ tracker was fitted to the participants and checked that they were comfortable. The eye-movement registration was calibrated using a 9-point grid so that the fixation mark corresponded precisely to the participant's point-of-gaze. An eye calibration was performed for each participant to verify point-of-gaze before the trials and periodic calibration checks were conducted during testing. After calibration, participants were presented with the six trials in the simulated task environment. These trials allowed participants to provide immediate retrospective verbal reports of thinking. Participants completed six

trials and each individual test session was completed in approximately 20 minutes. The order of presentation of the clips was kept consistent across all participants. Interviews were conducted after each trial, and consisted in one question: 'What were you thinking about while playing that point?', following the interview protocol reported by McPherson (2000) and adapted to the requirements of volleyball by Moreno, Moreno, Ureña, Iglesias and Del Villar (2008) and Araújo et al. (2011). In this protocol, immediately after each play the participant is removed from the court and inquired about his thoughts during the play. The participants had no time limit to respond.

Data analysis

Visual search data

Search rate comprised the *mean* number of fixation locations per trial, the mean number of fixations per trial and the mean fixation duration per trial in milliseconds. A fixation was defined as the period of time $\geq 100\text{ms}$ (≈ 3 video frames) when the eye remained stationary within 3° of movement tolerance (Panchuk & Vickers, 2006). The between-group differences were analyzed using a One-Way ANOVA with Group (skilled vs. less skilled) as the between-participants factor. Partial eta squared values (η^2_p) effect size measures were calculated.

Percentage viewing time was the percentage of time spent in fixation on each area of the display. The display was divided into ten locations: ball flight paths (subdivided into serve trajectory, reception trajectory, and setting trajectory); players that perform the action (subdivided into receiver, setter, attacker); players that are not performing an action (potential attackers); space (subdivided into between a potential attacker and the setter, and between the attacker and the blockers); and unclassified. The 'unclassified' category was included to account for all the fixations that did not fall within any of the other, and did not exceed 2% of total viewing time, indicating that the bulk of the data could be properly categorized in the established categories. Data were analyzed using a two-way ANOVA with Group (skilled vs. less skilled) as the between-participants factor and Fixation Location (ten locations as described

above) as the within-participants factors. Partial eta squared values (η^2_p) effect size measures were calculated. Significant main effects were followed up using Bonferroni-corrected pairwise comparisons. Interaction effects were followed up using Scheffé post hoc tests.

Verbal reports

Verbal statements were transcribed *verbatim* and encoded according to the model of protocol structure for tennis (McPherson, 2000), later adapted to volleyball (Araújo et al., 2011; Moreno et al., 2008). No *goal concepts* emerged, probably due to the purpose of defensive actions being highly implicit. Furthermore, no *action concepts* were registered. *Condition concepts* were encoded, referring to the conditions under which certain actions are applied in order to achieve the goal (e.g., the attacker was outside of the antenna). *Condition concepts* were further examined by considering two *hierarchical levels*: concepts about team members (level 1), and concepts about the opponents (level 2). Each identified condition concept was further classified according to one of the following four *levels of sophistication*: inappropriate or weak (quality level 0), appropriate without any details or features (quality level 1), appropriate with one detail or feature (quality level 2), and appropriate with two or more features (quality level 3). Regarding the *number of condition concepts*, *levels of sophistication*, and *hierarchical levels*, skill-based differences were analyzed using separate One-Way ANOVAs with Group as the between-participant factor. Partial eta squared values (η^2_p) effect size measures were calculated.

Reliability of the observation

Altogether, 26.7% of the data were randomly selected and re-analyzed. For *search rate* and *percentage viewing time*, Cronbach's Alpha ranged from 0.983 to 0.997 for intra-observer reliability and from 0.963 to 0.981 for inter-observer testing. Agreement concerning verbal reports' variables was determined with Cohen's Kappa. Intra-observer testing showed Kappa values between 0.906 and 1.000. Inter-observer values varied from 0.824 to 1.000.

Results

Visual search data

Search rate. There were significant skill-based differences in the mean fixation duration ($F(1, 88)=5.737$, $p=0.019$, $\eta^2_p=0.061$, see Table 1). The skilled participants employed longer fixations compared with the less skilled participants. There were no significant differences in the number neither of fixations nor of fixation locations. However, these results were close to statistical significance, as they presented p values under 0.085, indicating an error likelihood of less than 10%. There was a trend for less skilled participants presenting a higher number of fixations and of fixation locations.

Table 1 Differences in search rate per trial across groups

	Skilled	Less skilled	df	F	p	η^2_p
No. Fixations	5.17±1.42	5.75±1.59	1-88	3.296	0.073	0.036
Mean Fixation Duration (ms)	674.94±190.62	576.08±193.66	1-88	5.737	0.019	0.061
No. Locations	4.94±1.12	5.39±1.25	1-88	3.093	0.082	0.034

Percentage viewing time. With respect to percentage viewing time, significant Group x Fixation Location interaction was observed ($F(1, 414)=4.749$, $p\leq 0.001$, $\eta^2_p=0.094$). Post hoc Scheffé tests revealed that skilled participants spent significantly more time fixating the receiver ($30.9\pm 8.8\%$, $p=0.001$) and the space between the attacker and the blockers ($22.3\pm 6.6\%$, $p\leq 0.001$) compared to the less skilled participants (24.6 ± 10.5 and $8.9\pm 5.9\%$, respectively). In contrast, the less skilled participants spent significantly more time fixating on the attacker ($23.7\pm 6.6\%$, $p=0.013$) compared with their skilled counterparts ($18.3\pm 9.3\%$).

Verbal report data

Condition Concepts. There were significant skill-based differences in the number of condition concepts ($F(1, 88)=8.403$, $p=0.005$, $\eta^2_p=0.087$) (see Table 2). Skilled participants generated significantly more condition concepts than

their less skilled counterparts.

Level of Sophistication. Skill-related differences extended to the level of sophistication ($F(1, 85)=6.064$, $p=0.016$, $\eta^2_p=0.067$), with the skilled group presenting a superior level of sophistication. Specifically, the skilled group exhibited a value near 2, meaning their reports were usually appropriate and included one relevant detail or feature. Otherwise, the less skilled group was closer to 1, implying that many reports were appropriate but failed to include specific details or features.

Table 2 Differences in verbal reports across groups

	Skilled	Less skilled	df	F	p	η^2_p
No. Condition Concepts	1.96±0.91	1.44±0.70	1-88	8.403	0.005	0.087
Level of Sophistication	2.66±0.56	2.29±0.84	1-85	6.064	0.016	0.067
Hierarchical Level 1 – Team Members	1.13±0.73	0.50±0.51	1-88	20.315	≤0.001	0.188
Hierarchical Level 2 - Opponents	0.80±0.69	0.89±0.75	1-88	0.385	0.536	0.004

Hierarchical Levels. With respect to the hierarchical levels, differences between groups were found for level 1 – team members ($F(1, 88)=20.315$, $p\leq 0.001$, $\eta^2_p=0.188$), but not for level 2 – opponents. The skilled participants reported more condition concepts referring to their team members compared to the less skilled participants. Therefore, the superior number of condition concepts generated by the skilled players relies on the generation of a greater number of concepts related to their team members.

Discussion

We examined the mechanisms underpinning skilled performance in a dynamic, externally paced complex volleyball task using a representative simulated environment. Participants assumed a backcourt defensive position and had to follow attacking sequences from the opposing team. We recorded eye-movements concurrently and verbal reports of thinking retrospectively to provide a more thorough understanding of the processes underlying decision-

making in the task.

Our data showed that skilled players employed longer fixations. A trend was observed for less skilled players to make more fixations to a greater number of locations. This finding supports previous research conducted in volleyball where the skilled participants were shown to produce fewer fixations of longer duration compared to less skilled participants (Piras et al., 2010), even though this latter study was conducted in low-complexity settings. However, our results contradict previous studies in cricket and football that have shown that skilled players make more fixations of shorter duration to a higher number of locations in the visual display compared with their less skilled counterparts (McRobert et al., 2009; Roca et al., 2011). Therefore, although task complexity interferes with the product and process of performance (Williams et al., 2008), these data suggest that the inconsistent findings may be attributable to differences in the size and number of players involved in the trials, reflecting variations in task constraints. In the present case, our results support a more economical visual search pattern by skilled players, using fewer but longer fixations.

There were skilled-based differences in percentage viewing time, with skilled participants spending a greater amount of time fixating the space between the attacker and the blockers in comparison with the less skilled participants. Skilled players were therefore less dependent on the ball trajectory, being more likely to allocate attention towards other cues in the visual display (cf. Piras et al., 2010). A possibility is that skilled players are capable of simultaneously observing the attacker and the blockers, fixating on the functional space between them (cf., Roca et al., 2011), suggesting greater use of peripheral vision (Behrmann & Ewell, 2003; Williams et al., 2011). This enhanced utilization of peripheral vision denotes two important implications for practice: *a)* the fixation locations have to go beyond specific physical cues (e.g., ball, arm of the player) and move towards the concept of functional spaces (e.g., space between the setter and a probable receiver of the set); and *b)* it further underlines the need to complement visual data with verbal reports of thinking, in an attempt to clarify dubious situations.

The analysis of verbal reports revealed that skilled participants generated significantly more *condition concepts* than less skilled counterparts (cf., McPherson, 2000). Also, their statements presented *superior level of sophistication* in comparison to the less skilled peers, supporting findings in sports such as baseball (McPherson, 1993), tennis (McPherson & Kernodle, 2007) and volleyball (Araújo et al., 2011), and suggesting that skilled players possess a more detailed perception of the situation. Examination of the *hierarchical levels* revealed that skilled participants focused more on team members than their less skilled peers. This finding is consistent with our eye-movement data, which suggest that skilled players fixate more on the space between the attacker and the blockers, while the less skilled players fixate more on the attacker. This strategy allows the skilled players to better perceive the actions of their team's blockers, which has translated into differences in verbal reports of thinking. It should be highlighted that collecting verbal reports allowed confirmation of the appropriateness of the defined functional spaces. It also informs research that more than one method should be combined if there is interest in understanding the complex nature of a given phenomenon.

In summary, a complex, representative task was used to highlight skill-based differences in the *process* of analyzing visual displays. As research mainly uses simple, easier to control tasks, the utilization of a highly complex, game-like task aims to provide data that better translate into practical implications. Furthermore, it reveals that it is possible to conduct rigorous research in rich environments. Also, there remain only a limited number of reports where eye movement and verbal report data have been collected simultaneously (McRobert et al., 2009). In the present study, skilled players made longer fixations with a trend for making fewer fixations to a smaller number of locations than less skilled players. Skilled players fixated more often on functional spaces in comparison to less skilled participants, suggesting greater use of peripheral vision. In addition, skilled players generated more condition concepts and showed superior concept sophistication.

These data suggest that it is relevant to use tasks that simulate real-life environments, and this concept should be extended for domains other than

sport. More so, the definition of functional spaces, aiming for locations that stimulate retrieving information from more than one cue at a time, affords researches to use eye-tracking devices to analyze peripheral vision in addition to foveal vision. The collection of verbal reports allows understanding if those functional spaces were indeed relevant for the subjects. An implication of our data is that researchers need to be thoughtful when designing representative tasks in order to simulate as accurately as possible real competitive contexts (Ericsson & Ward, 2007).

What does this paper add?

The current paper contributes to research in decision-making in three major aspects. First, the utilization of a task that is representative of the game, using high-complexity plays that nearly reflect the reality of the game; using such game-like tasks is expected to provide data that are better generalizable for practice. The intention is to perceive the processes underpinning decision-making; therefore, their specific nature requires the development of highly specific tasks. This goes in line with the representative designs postulated by Brunswik (1955). Secondly, the combination of eye tracking data with verbal reports affords a more powerful tool to understanding the mechanisms underlying decision-making and their complexity. Although the possibility is rather simple, very few studies have applied both methods, and even fewer have done it in the same experiment. Finally, the definition of functional visual spaces (intermediate locations between two or more relevant visual cues) allows insights into cues perceived through peripheral vision. This expands the utilization of eye trackers, making it possible to go beyond a foveal vision analysis. The reliability of categorization of functional spaces was very high; also, crossing visual data with verbal reports further supported the relevance of defining such visual spaces. In conclusion, using representative designs, combining eye-tracking data with verbal reports of thinking, and defining functional visual spaces open promising avenues of research.

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The perceptual cognitive processes underpinning skilled performance in volleyball: Evidence from eye-movements and verbal reports of thinking involving an in situ representative task⁷

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Abstract

An extensive body of work has focused on the processes underpinning perceptual-cognitive expertise. The majority of researchers have used film-based simulations to capture superior performance. We combined eye movement recording and verbal reports of thinking to explore the processes underpinning skilled performance in a complex, dynamic, and externally paced representative volleyball task involving in situ data collection. Altogether, 27 female volleyball players performed as centre backcourt defenders in simulated sessions while wearing an eye-tracking device. After each sequence, athletes were questioned concerning their perception of the situation. The visual search strategies employed by the highly-skilled players were more exploratory than those used by skilled players, involving more fixations to a greater number of locations. Highly-skilled participants spent more time fixating on functional spaces between two or more display areas, while the skilled participants fixated on the ball trajectory and specific players. Moreover, highly-skilled players generated more condition concepts with higher levels of sophistication than their skilled counterparts. Findings highlight the value of using representative task designs to capture performance in situ.

Key words: Perceptual expertise; visual search behaviors; thought processes; *in situ* testing.

Introduction

An extensive body of research exists on perceptual-cognitive expertise in sport (Dicks et al., 2010; Ericsson and Williams, 2007; McPherson and Kernodle, 2007), as well as in dynamic and time-constrained activities such as driving (Wilson et al., 2008), the military (Janelle and Hatfield, 2008), and medicine (Patel et al., 1990). In the context of sport, athletes are required to closely integrate perceptual, cognitive and motor skills (Gréhaigne et al., 2001). In this vein, attention should be devoted to the processes underpinning expert performance (Ericsson, 2008; McRobert et al., 2009), preferably using tasks

that require athletes to combine perceptual, cognitive and motor skills in the same manner as during actual competition (Dicks et al., 2010). It is therefore essential to develop representative task designs that closely resemble the natural performance ecology in order to reveal the full nature of the expert advantage (Mann et al., 2010).

It has been well reported that experts quickly and accurately identify and recognize meaningful patterns in the scenarios (Laurent et al., 2006; Williams et al., 2011). The expert performer is better attuned to the task constraints and more accurate in anticipating the outcome of the action compared to less expert counterparts (McRobert et al., 2011). However, the nature and magnitude of these expertise-related differences varies to a lesser or greater extent depending on a number of factors such as the nature and complexity of the task (McRobert et al., 2011), and the experimental design employed (Button et al., 2011; Dicks et al., 2010). It appears that expertise is sport-, task-, and function-specific (Williams et al., 2008). As such, the superiority of experts over non-experts is enhanced as the task increases in complexity and specificity (Shim et al., 2005), implying the need to design representative experimental tasks that preserve task-specificity (Ericsson and Ward, 2007). However, as shown by the works of Dicks et al. (2010) and Mann et al. (2010), even simulated environments may not accurately grasp the processes that differentiate skilled from less-skilled individuals. An argument is that wherever possible it is important to try and capture performance in situ using the type of representative design proposed by Brunswik (1955).

Nonetheless, the majority of published work has involved the use of laboratory-based simulations. Although superior performance is typically reported when in film-based simulations are employed (e.g. Vaeyens et al., 2007), it is possible that different processes may be used when viewing film simulations compared to those employed during actual performance. In this vein, Araújo, Davids and Passos (2007) advanced the concern that such oversimplified research designs jeopardize the generalizability and of the findings to 'real-world' environments. There have been few empirical attempts to evaluate whether the processes that underpin performance differ when data is

collected using film-based simulations compared to in situ (Dicks et al., 2009). Some preliminary evidence exists to suggest that there may be some differences in the processes governing performance across these two types of tasks (Dicks et al., 2010; Mann et al., 2007; Williams et al., 2011).

The two most common methods to scrutinize the processes underpinning perceptual-cognitive expertise are the recording of gaze behaviors and the collection of verbal reports of thinking (Williams and Ericsson, 2005). Although the recording of gaze behavior may provide an indication of how attention is allocated, the relationship between gaze and attention is nonlinear (McPherson and Vickers, 2004). The lack of linearity between point of gaze and focus of attention may be particularly evident in experts (Laurent et al., 2006), who are known to rely more so than less expert individuals on peripheral vision and on kinesthetic and haptic information compared to non-experts (Behrmann and Ewell, 2003). Overall, decision-making implies the integration of sensory data from multiple sources into a composite, meaningful whole (Bogacz, 2007; Lenzen et al., 2009). In this line, the perceptual-cognitive perspective suggests that the expert performance approach should use a manifold of methods, namely combining eye-movement registration with collection of verbal reports of thinking (Ericsson and Williams, 2007; Williams et al., 2004).

According to a perceptual-cognitive account, verbal reports afford a window into the cognitive processes behind perception and action (McPherson and Thomas, 1989; Williams and Ericsson, 2005). Retrospective verbal reports have been applied to collect information concerning the practitioners' knowledge structures and in-event thoughts in a variety of domains (McPherson and Kernodle, 2007; McRobert et al., 2009; Roca et al., 2011). However, very few researchers have gathered eye-movement and verbal reports of thinking simultaneously during performance (for exceptions, see McRobert et al., 2011; Roca et al., 2011).

We examine the processes supporting skilled performance in a dynamic, externally paced volleyball task using a representative task design involving an in situ data collection. The task consisted of backcourt defensive scenarios involving 6 vs. 6 simulated offensive situations. The collection of eye-movement

registration and verbal reports of thinking were combined in an attempt to provide a more detailed understanding of the processes behind skilled performance in volleyball.

Methods

Participants

A total of 27 female volleyball players were recruited. Using procedures similar to those applied by Baker, Côté and Abernethy (2003), a panel of five expert coaches knowledgeable of the participants stratified them into highly-skilled or skilled groups based on an evaluation of their anticipation and decision-making skills. The inter-observer agreement percentages ranged from 88.9 to 96.3%. Highly-skilled participants ($n = 15$; mean age 19.1 ± 8.3 years) presented a mean of 9.2 ± 6.5 years of playing experience as starting players at elite national level teams within their age group. The skilled participants ($n = 12$; mean age 17.3 ± 4.2 years) had a mean of 5.8 ± 2.3 years of experience practicing at elite national level teams in Portugal. Participants signed an informed consent form and reported normal or corrected to normal levels of visual function. They were free to withdraw from testing at any stage. The institution's ethics guidelines were followed.

Materials and apparatus

A representative task environment was developed to evaluate participants' eye-movement behaviors and verbal reports of thinking in volleyball. Participants engaged in 6 vs. 6 situations during a training session on a standard volleyball court, acting as backcourt defenders in zone 6 (the back centre-area of the volleyball court; see Figure 1). Participants were free to move and interact with the action sequences, as they would do when playing in a real match. However, the starting point and area of responsibility was kept consistent across participants and trials.

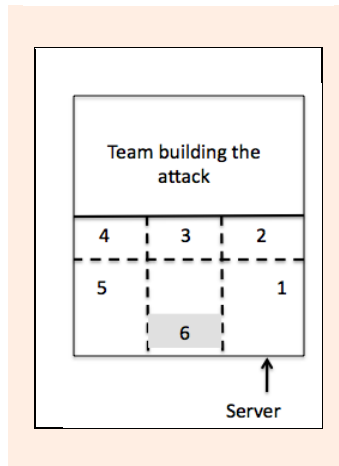


Figure 1. Experimental set-up. The participant in zone 6 is using the eye-tracker

The team under study was instructed to create the volleyball sequences, producing the serve and the subsequent serve-reception, setting, and attack. Each sequence started with a serve from behind the backcourt defender towards the opposite side, after which the other team would run an attack. Three players were in the defender's side of the net, acting as blockers (zones 2, 3 and 4), and two other players defended in lateral defensive positions (zones 5 and 1) near the sidelines (see Figure 1). These procedures were intended to recreate meaningful play situations. Participants would take turns in the backcourt defensive tasks. The experiment ended after six successful plays had been accomplished. The trials lasted approximately 5 seconds. The endpoint of each play occurred the moment the ball crossed the block, ensuring that initiation times and endpoints were standardized. In volleyball, the impossibility of making more than three contacts with the ball in each play means that no trial lasted more than five seconds. The visual search data were analyzed only until the ball pass to the defender's side of the net. In total, six trials per participant were considered for analysis. A panel of three expert volleyball coaches established the content and structure of these sequences. The action took place on a standard size volleyball court. The team's setters received detailed instruction and rehearsal regarding the scenarios that should emerge.

Participants' eye movements were recorded using the Applied Science Laboratories (ASL) 3000 MobileEye™ registration system (Bedford, MA, USA),

which is a video-based, monocular corneal reflection system that records eye point-of-gaze in relation to a head-mounted color scene camera. The system measures the relative position of the pupil and corneal reflection in relation to each other using an infrared light source. These features are then used to compute point-of-gaze by superimposing a crosshair onto the scene image captured by the head-mounted camera optics. The image is transferred to MiniDV format and later copied to the computer into an .avi file, and has a sampling frequency of 30Hz (30 frames per second). System accuracy was $\pm 0.5^\circ$ visual angle, with a precision of 0.5° in both the horizontal and vertical fields. The superimposed videos were analyzed twice in a frame-by-frame manner using Avidemux[®] 2.5.4. for Mac.

Verbal reports were collected using a Sony ICD-UX70 digital audio recorder. The .mp3 files were copied to an Apple MacBook Pro (2.4GHz Intel Core 2 Duo), opened with VLC Media Player version 1.1.111 and copied to a datasheet on Microsoft Excel[®] 2008 for Mac. Prior to testing, participants were provided with a detailed explanation on how to provide verbal reports of their thoughts (Botelho et al., 2011). They were expected to report cues that were relevant for their action.

Procedure

Before being tested, participants were familiarized with the experimental procedures. For each trial, participants were instructed to take up their ready defensive position and to try to defend the ball. In volleyball, the ready defensive position consists in assuming a small flexion of the ankles, knees and hips, with a slight internal rotation of the hips. The shoulders are slightly in front of the knees and arms are loose (Selinger and Ackermann-Blount, 1986). Participants were positioned in backcourt zone 6. Prior to engaging in the actual trials, the MobileEye[™] tracker was fitted to the participant's head and checked to ensure that it was comfortable and that interference with performance would be kept to a minimum. The eye movement registration system was calibrated using 5 non-linear points in the scene image so that the recorded indication of fixation position corresponded to each participant's point-of-gaze. An eye

calibration was performed for each participant to verify point-of-gaze before the trials and regular calibration controls were conducted during testing. Namely, re-calibration was conducted whenever: a) the participant occasionally made a fall; b) the ball was defended near to the face (implying a vigorous movement of the head); c) the team performing the plays would commit to many fails, prolonging the duration of the testing; d) the participant complained about sweating too much, with drops of sweat in the forehead or eyes' region, as such drops may impair the functioning of the infrared camera; and e) the participants made arm movements that contacted the goggles and/or the cables. Additionally, random re-calibrations were at times conducted.

Following calibration and instruction, participants stepped into the court and acted as backcourt defenders for as many trials as needed until six trials had been successfully ran. Trials where the team building the attack would fail to make a play or where there was a missed serve were not considered. Interviews were conducted after each trial, and consisted of one question: 'What were you thinking about while playing that point?' This recall interview is part of the protocol reported by McPherson (2000), adapted to the requirements of volleyball by Moreno, Moreno, Ureña, Iglesias, and Del Villar (2008) and Araújo, Afonso and Mesquita (2011). Participants were instructed to leave the court after each successful trial and respond as accurately as possible to the question concerning their thoughts during the trial. There was no time limit to respond and additional feedback was provided when necessary. Participants completed six trials and each individual test session was completed in approximately 20-25 minutes.

Data analysis

Visual search data

Search rate included the *mean* number of fixation locations per trial, the mean number of fixations per trial and the mean fixation duration per trial, measured in milliseconds (Roca et al., 2011). A fixation was defined as the period of time $\geq 100\text{ms}$ (≈ 3 video frames) when the eye remained stationary within 3° of movement tolerance (Panchuk and Vickers, 2006). The between-

group differences were analyzed using a One-Way ANOVA with Group (skilled vs. less skilled) as the between-participants factor. Partial eta squared values (η^2_p) effect size measures were calculated.

Percentage viewing time referred to the percentage of time spent in fixation on each area of the display (Dicks et al., 2010). Ten locations were defined: ball trajectories (subdivided into serve trajectory, reception trajectory, and setting trajectory); players performing the action (subdivided into receiver, setter, attacker); players that are not performing an action but may play a role in the action (potential attackers); space (subdivided into space between a potential attacker and the setter, and space between the attacker and the blockers); and unclassified. The 'unclassified' category was incorporated to report all the fixations that fell outside the scope of the other categories (McRobert et al., 2009), although these did not exceed 1% of the occurrences. Data were analyzed using a Two-Way ANOVA with Group (skilled vs. less skilled) as the between-participants factor and Fixation Location as the within-participants factors. Partial eta squared values (η^2_p) effect size measures were calculated. Significant main effects were followed up using Bonferroni-corrected pairwise comparisons. Interaction effects were followed up using Scheffé post hoc tests.

Verbal reports

The participants' statements were transcribed *verbatim* and encoded according to the model of protocol structure for tennis (McPherson, 2000), adapted to volleyball (Araújo et al., 2011; Botelho et al., 2011; Moreno et al., 2008). This adapted protocol includes goal concepts (which refer to the purposes of a chosen action within the context of the game), action concepts (referring to the action selected and its relevance in a specific situation), and condition concepts (specifying under which conditions the action occurred). As reported by Botelho et al. (2011), no *goal concepts* were articulated. We believe this reflects the nature of the defensive task in volleyball. In fact, the main goal is to play the ball towards the zone where the setter plays, with sufficient height to afford all setting options. As such, participants didn't verbalize any goals,

presumably because they are implied. Additionally, no *action concepts* were mentioned, which may relate to the experimental design, since use of the eye-tracker inhibits the action of defense to some extent. Although participants actually moved on the court and tried to defend the ball, they could not, for example, fall to the floor, defend and roll, therefore limiting their action possibilities. Therefore, participants would intercept the ball on some, but not all trials. *Condition concepts* were encoded with regard to the conditions surrounding game actions (e.g., the set was too close to the net). As the task consisted of a play by the opponent without a follow-up of the rally, and lasting under 5 seconds, there was only a limited set of information available; hence, the concepts weren't further divided into sub-concept categories.

These condition concepts were further examined with regard to their *hierarchical levels*, considering concepts about team members (level 1), and concepts about the opponents (level 2). The hierarchical level 0 (concepts about themselves) did not emerge in our study. The recorded concepts were additionally classified according to their *level of sophistication*, which reflects the appropriateness and level of detail of the verbal reports. Four levels were considered: inappropriate or weak (quality level 0), appropriate but without any details or features (quality level 1), appropriate with one detail or feature (quality level 2), and appropriate with two or more features (quality level 3). The appropriateness of the concepts was evaluated by comparing the reports with the video images of the corresponding situation, which were available through the eye-tracker's scene camera. Skill-based differences in the *number of condition concepts*, *levels of sophistication*, and *hierarchical levels* were analyzed using a Mann-Whitney *U* test with Group as the between-participant factor. Effect size measures were calculated through the formula $r=Z/\sqrt{N}$.

Reliability of the observation

The reliability of the data was established using the intra-observer and the inter-observer agreement methods. Altogether, 22.2% of the data were randomly selected and re-analyzed to provide agreement figures using the procedures recommended by Tabachnick and Fidell (2007). For *search rate*

and *percentage viewing time*, Cronbach's Alpha ranged from 0.954 to 0.977 for intra-observer reliability and from 0.900 to 0.947 for inter-observer testing. Agreement concerning verbal reports' variables was determined with Cohen's Kappa. Intra-observer testing showed Kappa values between 0.931 and 1.000. Inter-observer values varied from 0.807 to 1.000.

Results

Visual search data

Search rate There were significant skill-based differences in the number of fixations ($F_1 = 4.792$, $p = 0.030$, $\eta^2_p = 0.029$) and number of fixation locations ($F_1 = 4.238$, $p = 0.041$, $\eta^2_p = 0.026$, see Table 1). The search behaviors of highly-skilled participants involved more fixations to a greater number of different locations compared with the skilled participants. The skilled participants presented superior mean fixation durations than the highly-skilled participants, but with no statistical significance.

Table 1. Differences in search rate per trial across groups. Data are means ($\pm$ SD).

	Highly-skilled	Skilled	df	F	p	η^2_p
No. Fixations	5.99 (1.33)	5.56 (1.15)	1	4.792	.030 *	.029
Mean Fixation Duration (ms)	596.29 (165.70)	627.15 (163.01)	1	1.408	.237	.009
No. Locations	5.76 (1.12)	5.40 (1.04)	1	4.238	.041 *	.026

* Significant for the 0.05 level

Percentage viewing time A main effect was found for Fixation Location ($F_9 = 54.559$, $p \leq 0.001$, $\eta^2_p = 0.365$), but not for Group. However, a significant Group x Fixation Location interaction emerged ($F_9 = 6.321$, $p \leq 0.001$, $\eta^2_p = 0.062$). Post hoc Scheffé tests revealed that highly-skilled participants spent significantly more time fixating the receiver ($22.28 \pm 6.96\%$) and the space between the attacker and the blockers ($24.92 \pm 7.88\%$) compared to the skilled participants (18.36 ± 6.79 and $18.77 \pm 10.27\%$, respectively). In contrast, the skilled participants spent significantly more time fixating on the attacker ($27.15 \pm 7.61\%$) compared with their highly-skilled counterparts ($19.40 \pm 11.87\%$).

Verbal report data

Condition Concepts Significant skill-based differences in the number of condition concepts were observed ($U = 1985.50$, $z = -4.548$, $p \leq 0.001$, $r = 0.357$, see Table 2). The highly-skilled participants generated significantly more condition concepts than their skilled peers. For example, a skilled participant would mention an aspect related to the block, while a highly-skilled participant would mention aspects related to the block, the attacker, and the setter.

Level of Sophistication Skill-related differences emerged with respect to the level of sophistication ($U = 1881.00$, $z = -4.423$, $p \leq 0.001$, $r = 0.355$), with the highly-skilled group showing a superior level of sophistication. As an example of a report with a hierarchical level 0, a skilled participant mentioned 'the block was open' [meaning that there was space for the ball to pass between two blockers], but video data showed that, clearly, it was not.

Table 2. Differences in verbal reports across groups

	Highly-skilled <i>Mean rank</i>	Skilled <i>Mean rank</i>	U	z	P	r
No. Condition Concepts	95.44	64.08	1985.50	-4.55	≤ 0.001 *	.357
Level of Sophistication	89.60	61.94	1881.00	-4.42	≤ 0.001 *	.355
Hierarchical Level 1 – Team Members	85.38	76.65	2891.00	-1.37	.172	.108
Hierarchical Level 2 – Opponents	91.99	68.38	2295.50	-3.43	.001 *	.269

* Significant for the 0.05 level

A highly-skilled participant, in a similar situation, mentioned 'block on time, middle-blocker was late', a level 3 report, since it presents at least two features and is appropriate to the situation.

Hierarchical Levels There were significant differences across groups for hierarchical level 2 – opponents ($U = 2295.50$, $z = -3.426$, $p \leq 0.001$, $r = 0.269$), but not for level 1 – team members. The highly-skilled participants produced more condition concepts referring to their opponents (namely the attackers) compared to the skilled participants, with this event explaining the superior

number of condition concepts produced by highly-skilled players.

Discussion

We explored the processes supporting skilled performance in a dynamic, externally paced volleyball task using a representative design involving in situ data collection. Participants played in a 6 vs. 6 simulated sequences as centre backcourt defenders, while eye movements and immediate retrospective verbal reports of thinking were collected. We reported the visual search behaviors and verbal reports of thinking underpinning skilled performance in a live-action representative task. Although some movements were limited by the usage of the eye-tracker device (e.g.: to fall and roll), participants could move in the court and they actually tried to intercept the ball.

Our data showed that highly-skilled players employed significantly more fixations to a greater number of locations than skilled players, as previously reported in cricket (McRobert et al., 2009) and soccer (Roca et al., 2011). It has been suggested that more efficient search patterns involve fewer fixations of longer duration and appear to be linked to expert performance (Mann et al., 2007; Piras et al., 2010). However, complex sports may benefit from different visual strategies, making a larger number of shorter fixations to several locations (North et al., 2009). It is apparent that the nature of the task strongly influences the processes underpinning decision-making.

Skill-based differences emerged with respect to percentage viewing time, with highly-skilled participants spending more time fixating on functional spaces, especially just before and during ball contact, as previously reported in soccer (Roca et al., 2011). By fixating on these functional spaces, the participants may be able to retrieve a greater amount of information simultaneously through more effective use of peripheral vision (Behrmann and Ewell, 2003; Laurent and Ripoll, 2009; Williams et al., 2011).

Verbal reports showed that highly-skilled participants generated significantly more condition concepts than the skilled counterparts (cf., McPherson, 2000). As condition concepts reflect the attunement to the surrounding constraints, a superior number of condition concepts may suggest

that the highly-skilled participants are better attuned to the task constraints. In support of this idea, highly-skilled participants produced statements that were more sophisticated in comparison to the skilled participants, corroborating previous reports involving baseball (McPherson, 1993), tennis (McPherson and Kernodle, 2007) and volleyball (Botelho et al., 2011). A clear link emerged between visual search behaviors and a more sophisticated knowledge base (expressed through verbal reports of thinking), in the sense that experts attended more to functional spaces, allowing them to capture richer information concerning game problems, which translated into generating more condition concepts of superior sophistication. Furthermore, similar amounts of verbal reports were produced with regard to team-mates, but highly-skilled participants produced more concepts concerning their opponents in comparison to their skilled peers. Hence, highly-skilled participants are better attuned to game constraints created by the opponents.

Conclusion

In conclusion, a representative volleyball task was created involving live-action situations with the purpose of examining skill-related differences in perceptual-cognitive expertise. Although motor responses were not evaluated, they were included in the task, in order to better respect the specific perception-action couplings of real-life situations, therefore capturing more accurately the nature of the skill-based differences (Dicks et al., 2010; Mann et al., 2010). The visual search behaviors of highly-skilled players were more exploratory than those of their skilled counterparts, with highly-skilled players employing more fixations to a greater number of locations. The highly-skilled players spent more time fixating functional spaces (i.e. areas that are intermediate to a number of cues of interest). Furthermore, highly-skilled participants generated significantly more condition concepts than skilled participants, with these statements being of superior quality, potentially reflecting better attunement to the task constraints. Overall, it was established that highly-skilled players present superior ability in detecting relevant information in the visual display (Laurent et al., 2006; McPherson and MacMahon, 2008). The perceptual-cognitive account

often distinguishes declarative and procedural knowledge (Thomas and Thomas, 1994). Perhaps verbal reports of thinking provide a measure of the former, with gaze behavior affording a measure of the latter.

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Visual search behaviours and verbal reports of thinking during film-based and in situ representative tasks in volleyball⁸

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Abstract

Several researchers have explored the processes underlying perceptual-cognitive expertise, mainly using film-based studies. However, few have compared the extent to which data from film-based settings differs from those obtained through in situ collection. This gap in the literature is a relevant concern, since scientific research is used to provide guidance for designing training programs. In this paper, eye movement recording and verbal reports of thinking were combined to explore the processes underpinning skilled performance in a representative volleyball task involving both film-based and in situ data collection. Nine volleyball players performed as backcourt defenders while wearing an eye-tracking device and providing verbal reports of thinking after each sequence. A number of significant differences were observed between the data gathered under film-based and in situ conditions. Namely, in the in situ condition participants employed longer fixations (728.11 ± 129.27 ms) than in the film condition (659.57 ± 178.06 ms) and there were differences in the nature of the fixation locations. With respect to verbal reports, participants exhibited superior level of sophistication in the in situ condition (2.57 ± 0.50 versus 2.30 ± 0.84 in the film condition), while denoting a greater concern with the opponents under this condition (1.00 ± 0.73) than in the film condition (0.59 ± 0.60). These differences emerged despite task design and constraints being highly similar. No differences were apparent in the number of gaze fixations and fixation locations across conditions or in the number of verbalized condition concepts. Although exploratory, our data suggest that the mechanisms underpinning skilled decision-making in sports differ between film-based and *in situ* conditions.

Keywords: perceptual expertise; test design; task specificity

Introduction

The ability to make accurate and well-timed decisions is crucial to performance at the elite level (Roca, Ford, McRobert & Williams, 2011; Williams, Ford, Eccles & Ward, 2011). So far, it has been demonstrated that expertise is highly sport- and function-specific (Abernethy, Baker & Côté, 2005) and that the perception-action couplings supporting decision-making are context-specific (Passos, Araújo, Davids & Shuttleworth, 2008). In this vein, representative simulated environments may not suffice to fully understand the processes underlying decision-making (Dicks, Button & Davids, 2010; Mann, Abernethy & Farrow, 2010). There is a need for researchers to develop representative task designs (Brunswik, 1955; Ericsson & Ward, 2007), as the magnitude and nature of the expertise-based differences may depend on the specificity of the task (Ericsson, 2008; Vaeyens, Lenoir, Williams, Mazyn & Philippaerts, 2007). In a meta-analysis of 42 papers conducted by Mann, Williams, Ward and Janelle (2007), experts consistently outperformed non-experts, but the magnitude of the expertise-based differences was more evident as the task and experimental designs were more closely aligned with the demands of competition.

Although some researchers have collected verbal reports in live-action settings (cf. McPherson, 2000; McPherson & Kernodle, 2007), most work using eye movement registration techniques are film-based, as demonstrated by existing work in cricket (McRobert, Ward, Eccles & Williams, 2011), football (North, Williams, Hodges, Ward & Ericsson, 2009), and volleyball (Piras, Lobietti & Squatrito, 2010). The use of film-based simulations reduces the three-dimensional world to a two-dimensional display (Mann et al., 2007), presents reduced image size (Al-Abood, Bennett, Moreno, Ashford, & Davids, 2002), and induces different visual search behaviours compared to live action settings (Button, Dicks, Haines, Barker & Davids, 2011; Dicks et al., 2010), all of which it affects visual search behaviours. Therefore, it is important to design a representative task and compare players' decisional processes between a

laboratory setting and a live-action context to promote a further understanding of the nature and magnitude of the differences.

Within this framework, some researchers suggest that skilled players tend to use more global and efficient visual search behaviours, making fewer fixations of longer duration to a smaller number of locations, compared to less skilled players, (cf. Huys & Beek, 2002, Piras et al., 2010; Ripoll, Kerlirzin, Stein & Reine, 1995). However, results are controversial (cf. North et al., 2009; Roca et al., 2011) and it is now considered that visual search strategies vary considerably across sports as well as within each sport, depending on the specific task (Mann et al., 2007; Vaeyens et al., 2007). The same trend is found with respect to fixation (McRobert, Williams, Ward & Eccles, 2009; Piras et al., 2010; Roca et al., 2011). Furthermore, attention may be distinct from point of gaze because of the role of peripheral vision and kinaesthetic information (Huys & Beek, 2002; Tenenbaum, 2003; Vickers, 2009).

These findings support the need for research on decision-making to combine eye movement registration and verbal reports of thinking (Ericsson & Williams, 2007; McPherson & Vickers, 2004), which provide a window into the players' cognitive processes during competition (McPherson & Kernodle, 2007), and allow differentiating between experts and non-experts, as shown by research in baseball (McPherson & MacMahon, 2008), football (Roca et al., 2011), tennis (McPherson & Kernodle, 2007) and volleyball (Botelho, Afonso, Araújo & Mesquita, 2011). However, verbal reports themselves present some limitations, as they frequently generate misleading summaries or after-the-fact reconstructions (Araújo, Travassos & Vilar, 2010). In some occasions, the players are simply incapable of verbalizing their procedure knowledge (McPherson, 1994). Indeed, motor learning is highly implicit, meaning that verbal reports on motor actions tend to be imprecise and not very reliable (Seidler, 2010).

Therefore, the combination of eye movement registration and verbal reports of thinking could afford powerful insights into the processes underpinning skilled decision-making, but few researchers have sought to combine these two process-tracing measures during performance. There are a

few exceptions, such as the work of Roca et al. (2011) with football players, although the two measures were taken in different experiments. McRobert et al. (2009) using cricketers and McPherson and Vickers (2004) with volleyball players collected both data sets within one experiment.

Our purpose in this paper was to analyze the nature and magnitude of the differences in the process of decision-making between film-based and in situ data collection. A representative and complex volleyball task was created, attempting to reproduce the constraints observed in real-life settings. Participants were submitted to both experimental conditions. Eye movement registration and verbal reports of thinking were collected concurrently to provide a deeper understanding of the processes underpinning decision-making.

Methods

Participants

Nine female volleyball players were recruited (14.9 ± 0.3 years of age). They had a mean of 5.0 ± 1.2 years playing experience at an elite national level for their specific age group. The study was approved by the Foundation for Science and Technology — Ministry of Science, Technology and Superior Teaching of Portugal and followed the University of Porto's Ethics Committee guidelines. The participants and their parents were fully informed of its procedures and purposes and provided written consent to participate in this study. Participants were healthy and reported normal or corrected to normal levels of visual function. They were free to withdraw from testing at any stage.

Materials and apparatus

In the *film-based condition*, participants watched stimuli that were back-projected (Epson EMP-S3 3LCD Projector) onto a large screen (1.8 m height x 2 m wide) placed 4 m in front of them. The film clips were played through QuickTime Player® for Mac (version 10.1). Participants were free to move. Twelve female (mean age 22.9 ± 4.7 years), top national level volleyball players were invited to produce the film-based sequences and instructed to create game sequences at their will. The selection of the intended scenarios would be

made after the session. A digital HD video camera (Sony Handycam HDR-XR550VE) was used to record the film stimuli from a backcourt perspective at a frequency of 60Hz. The camera was situated at a slightly elevated perspective (approximately 3 m) near the endline of the serving team, in order to enable the entire width of the playing field to be viewed and to improve perception of depth. Each film sequence involved a serve from behind the camera towards the opposite side, and the opposing team would run an attack in response to the serve. Five players simulated the server's team, three performing blocking actions in the net (zones 4, 3 and 2), two defending in the lateral defensive positions (zones 1 and 5; see Figure 1). The scenarios were approximately 5 seconds in length, and the endpoint for visual search data was the moment in which the ball crossed the net, to ensure standardization of the sequences initiation times and endpoints.

Six film sequences were produced and the filming was conducted on a standard size volleyball court. Filming was conducted over a 2-hour session and a panel of three specialist volleyball coaches selected the six trials deemed most representative of the game. The selected game patterns had to be similar to those used with younger players; hence, more evolved game patterns were not selected. The footage was digitally edited using Apple iMovie'09 to assemble a number of six short clips to be used in the film-based task. Before the beginning of each clip, a black screen with a centred numbered countdown (3-2-1) was shown, to set up the participants for visualization.

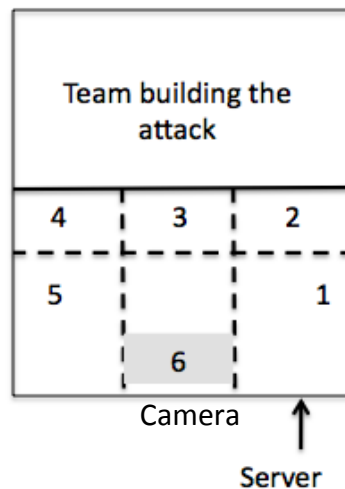


Figure 1 Experimental set-up. The participant in zone 6 is using the eye-tracker.

In the *in situ condition*, participants engaged in 6 vs. 6 simulated situations during training sessions on a standard volleyball court, where they assumed a backcourt defence position in zone 6 (the centre backcourt area; see Figure 1) and were free to move and interact with the action sequences, as they would do when playing in a match. The teams had to serve and to create game sequences. The experiment finished after six successful attack trials had unfolded. The trials had to be identical to those used in the film-based condition, and standardization procedures were applied, with each sequence lasting around five seconds and having the same beginning and endpoints.

In *both experiments*, an Applied Science Laboratories (ASL) 3000 MobileEye™ registration system (Bedford, MA, USA) was used to collect gaze data. This is a video-based, monocular corneal reflection system that registers eye point-of-gaze in relation to a head-mounted colour scene camera. It operates by measuring the relative position of the pupil and corneal reflection in relation to each other using an infrared light source. This information is used to calculate point-of-gaze by superimposing a crosshair onto the scene image captured by the head-mounted camera optics. The image is transferred to MiniDV format and copied to a computer as an .avi file at a sampling frequency of 30Hz. System accuracy was $\pm 0.5^\circ$ visual angle, with a precision of 0.5° in

both the horizontal and vertical fields. The superimposed videos were analyzed twice in a frame-by-frame manner using Avidemux[®] 2.5.4. for Mac.

Verbal reports of thinking were recorded by means of a Sony ICD-UX70 digital audio recorder. The .mp3 files were copied to an Apple MacBook Pro (2.4GHz Intel Core 2 Duo), opened with VLC Media Player version 1.1.111 and copied to a datasheet on Microsoft Excel[®] 2008 for Mac. Prior to testing participants were provided with a detailed explanation on how to provide verbal reports of their thoughts (Araújo, Afonso, & Mesquita, 2011).

Procedure

Participants were provided with information concerning the experiment and a demonstration of the simulated task environment. They also had the chance to participate in one or two pre-test trials, and to present any doubts concerning their action and on providing verbal reports. In both conditions, participants were instructed to assume their ready defensive position and to try and defend the ball in each trial. The MobileEye[™] tracker was fitted to the participants. The eye-movement registration was calibrated so that the recorded indication of fixation position corresponded to each participant's point-of-gaze. In the film-based condition, a 9-point grid was used and 5 different points were fixated; in the in situ condition, 5 non-linear points in the scene image were used (McRobert et al., 2009; Roca et al., 2011). An eye calibration was performed for each participant to verify point-of-gaze before the trials.

Following calibration, participants were provided with instructions on how to present immediate retrospective verbal reports. Subsequently, participants assumed their position with regard to the screen, in the film-based condition, or stepped into the court and acted as backcourt defenders for as many trials as needed until the six different scenarios had been ran in the in situ condition. Recall interviews were realized after each trial, consisting of a single question (McPherson, 2000): 'What were you thinking about while playing that point?' This question was specifically developed for application during simulated game situations and has been used in studies conducted in volleyball (Araújo et al., 2011; Moreno, Moreno, Ureña, Iglesias, Del Villar, 2008). There was no time

limit to respond and additional feedback on generating verbal reports was provided when necessary.

Participants completed six trials in each condition. Testing lasted around 10 minutes for the film-based condition and between 15-20 minutes for the *in situ* condition (excluding instructions and calibration procedures). In the *in situ* condition, participants completed between eight to seventeen trials until the same six from the film-based condition were obtained.

Data analysis

Visual search data

Search rate includes the *mean* number of fixation locations, the mean number of fixations and the mean fixation duration per trial, measured in milliseconds (Dicks et al., 2010). A fixation was defined as the period of time $\geq 100\text{ms}$ (roughly 3 video frames) when the eye remained motionless within 3° of movement tolerance (Panchuk & Vickers, 2006). The between-condition differences on each variable were analyzed using a One-Way ANOVA with Condition (film vs. in situ) as the between-participants factor. Partial eta squared values (η^2_p) effect size measures were calculated.

Percentage viewing time is the percentage of time spent fixating on each area of the display (Dicks et al., 2010). Ten locations of the visual display were defined: ball trajectories (subdivided into serve trajectory, reception trajectory, and setting trajectory); players performing the action (subdivided into receiver, setter, attacker); players that are not performing an action but may play a role in the action (potential attackers); space (subdivided into space between a potential attacker and the setter, and space between the attacker and the blockers); and unclassified. The 'unclassified' category was incorporated to report all the fixations that fell outside the scope of the other categories (Roca et al., 2011), and did not exceed 1% of the occurrences. Data were analyzed using a Two-Way ANOVA with Condition (film vs. in situ) as the between-participants factor and Fixation Location as the within-participants factors. Partial eta squared values (η^2_p) effect size measures were calculated. Significant main effects were followed up using Bonferroni-corrected pairwise

comparisons. Significant interaction effects were followed up using Scheffé post hoc tests.

Verbal reports

Verbal statements were transcribed and encoded following the model of protocol structure for tennis (McPherson, 2000) and adjusted to volleyball (Araújo et al., 2011; Botelho et al., 2011; Moreno et al., 2008). Units of information were classified according to three main categories: goal concepts; condition concepts; and action concepts. *Condition concepts* describe conditions supporting game actions (e.g., the attacker aimed at crosscourt). Consistent with the findings of Botelho et al. (2011), participants failed to mention *goal concepts* (e.g.: 'to put the ball in good conditions for the setter'). Since volleyball is a non-invasion game, the goal of defence is to put the ball in good conditions for the team to put up a counter-attack. In this context, goals are implicit to the task, thus participants do not generate such verbal statements. Moreover, no statements concerning *action concepts* were produced (e.g.: 'I tried rotating to the right to intercept the ball').

Condition concepts were further analyzed concerning their *hierarchical levels*: concepts about skill and themselves (level 0); concepts about team members (level 1); concepts about the opponents (level 2); and concept goals or conditions of other nature (level 3). Hierarchical level 3 was excluded from the analysis since all the codes could be integrated in the previous levels. Condition concepts were also classified according to their *level of sophistication*, a measure of the appropriateness and level of detail of the statements, including: inappropriate or weak (quality level 0), appropriate without any details or features (quality level 1), appropriate with one detail or feature (quality level 2), and appropriate with two or more features (quality level 3). The level of sophistication was evaluated comparing the verbal reports with video images from the corresponding situation, available through the eye-tracker's scene camera. Differences in the *number of condition concepts*, *levels of sophistication*, and *hierarchical levels* related to the experimental conditions were analyzed using a One-Way ANOVA with Condition as the between-

participant factor. Partial eta squared values (η^2_p) effect size measures were calculated.

Reliability of the observation

Data reliability was established using the intra- and inter-observer agreement methods. In total, 22.2% of the data were randomly selected and re-analyzed to provide agreement figures using the procedures recommended by Tabachnick and Fidell (2007). For *search rate* and *percentage viewing time*, Cronbach's Alpha ranged from 0.95 to 0.98 for intra-observer reliability and from 0.90 to 0.95 for inter-observer testing. Agreement concerning verbal reports was determined with Cohen's Kappa. Intra-observer testing showed Kappa values between 0.84 and 1.00. Inter-observer values varied from 0.84 to 1.00.

Results

Visual search data

Search rate. Significant differences were observed between experimental conditions in mean fixation duration ($F_1=5.24$, $p=0.02$, $\eta^2_p=0.05$) (see Table 1). Visual search strategies in the *in situ* condition involved longer fixations compared with the film condition. No other effects were significant.

Table 1 Differences in search rate per trial across groups

	Film	In situ	df	F	p	η^2_p
No. Fixations	5.15±1.38	5.35±0.91	1	0.82	0.37	0.01
Mean Fixation Duration (ms)	659.57±178.06	728.11±129.27	1	5.24	0.02*	0.05
No. Locations	4.98±1.09	5.30±0.86	1	2.77	0.10	0.03

* Significant for the .05 level

Percentage viewing time With regard to percentage viewing time, a significant main effect for fixation location was registered ($F_9=36.90$, $p\leq 0.001$, $\eta^2_p=0.39$). A significant Experimental Condition x Fixation Location interaction was observed ($F_9=5.50$, $p\leq 0.001$, $\eta^2_p=0.09$). Post hoc Scheffé tests revealed that participants spent significantly more time fixating the attacker ($26.84\pm 6.62\%$) in the *in situ* condition compared to the film condition ($19.93\pm 8.21\%$). In contrast, in the film

condition participants spent significantly more time fixating on the receiver ($26.99 \pm 9.14\%$) and potential attacker ($19.92 \pm 4.27\%$) compared with the *in situ* condition (22.08 ± 6.73 and $5.09 \pm 0.86\%$, respectively).

Verbal report data

Number of Condition Concepts There were no significant differences with regard to the number of condition concepts (see Table 2).

Level of Sophistication There were differences in the level of sophistication ($F_1=3.99$, $p=0.05$, $\eta^2_p=0.04$), with the participants presenting a superior level of sophistication in the *in situ* condition, although the proof value is marginal.

Table 2 Differences in verbal reports across groups

	Film	In situ	df	F	p	η^2_p
No. Condition Concepts	1.54 ± 0.57	1.52 ± 0.80	1	0.02	0.89	≤ 0.001
Level of Sophistication	2.30 ± 0.84	2.57 ± 0.50	1	3.99	0.05*	0.04
Hierarchical Level 1 – Team Members	0.87 ± 0.62	0.52 ± 0.54	1	9.96	0.002*	0.09
Hierarchical Level 2 - Opponents	0.59 ± 0.60	1.00 ± 0.73	1	10.10	0.002*	0.09

* Significant for the .05 level

Hierarchical Levels There were between-conditions differences for both level 1 – team members ($F_1=9.96$, $p=0.002$, $\eta^2_p=0.09$) and level 2 – opponents ($F_1=10.10$, $p=0.002$, $\eta^2_p=0.09$). In the *in situ* condition, participants generated a greater number of condition concepts referring to the opponents, whereas in the film condition they presented a superior number of condition concepts with respect to team members.

Discussion

In order to better understand the processes underpinning skilled decision-making, it is necessary to design experimental conditions that reproduce as best as possible the task specificity and complexity exhibited in real-life contexts (Ericsson & Ward, 2007). Nonetheless, existing work has mainly relied on laboratory tasks (e.g., McRobert et al., 2009), with only a few

studies involving live-action designs (e.g., Lee, 2010). Furthermore, there have been few attempts to compare between the two task conditions (e.g. Bruce, Farrow, Raynor & Mann, 2012; Dicks et al., 2010). Therefore, we explored the mechanisms underpinning decision-making in a representative and complex volleyball task, comparing two distinct conditions: film-based versus in situ data collection. The tasks were made as similar as possible in order to standardize experimental conditions (e.g.: the same scenarios were recreated and in both cases they were allowed to move). Participants' eye movements and immediate retrospective verbal reports of thinking were recorded.

With respect to visual search rate, participants exhibited strategies involving longer fixations in the in situ condition in comparison to the film-based condition. This finding contradicts that reported by Button et al. (2011) where longer durations were reported under film compared with in situ conditions. As the length of the scenarios was standardized, longer fixations may induce a fewer number of fixations to less fixation locations. There were also differences between the two experimental conditions for percentage viewing time. Participants spent more time fixating on the attacker in the in situ condition, while in the film-based condition more time was spent fixating a potential attacker. The difference between attacker and potential attacker presents an important functional difference. An attacker is a player that was previously solicited by the setter; the ball was set and it was overtly known that attacker would be responsible for contacting the ball and performing the attack. In turn, a potential attacker is any player who is ready to attack the ball, but the ball hasn't been set yet. Therefore, fixating on a potential attacker means the participant is attending to a potential anticipatory cue.

These differences may be related to image size, since this factor is known to influence visual search strategies (Al-Abood et al., 2002). As distances between distinct points of interest become reduced in the film-based condition, it is easier for participants to attend to cues emerging in their peripheral vision (case in point: movements from certain attackers before the setting), while in the *in situ* condition they will tend to focus more closely on the ball and on the players more closely involved in the move. Furthermore, the *in*

situ condition affords a real possibility of contacting the ball, therefore presenting a different challenge than that of the film-based condition. This seems to confirm that the mechanisms underpinning perception and decision-making are highly dependent on the nature of the experimental tasks (Dicks et al., 2010; Mann et al., 2010).

With regard to verbal reports of thinking, no differences emerged in the number of condition concepts generated by the participants across both experimental conditions. However, the level of sophistication associated with the generated concepts was superior in the *in situ* condition in comparison to the film-based condition, even though statistical significance was marginal ($p=0.05$); hence, caution is warranted when drawing conclusions. As participants are trained and prepared to perform under *in situ* conditions and not under film-based conditions, they may be better attuned to the *in situ* conditions highlighting the task-specific nature of expertise (Abernethy et al., 2005; Ericsson & Lehmann, 1996; Passos et al., 2008). The possibility to actually intercept the ball may be modulating such differences, as it has been demonstrated that the possibility to engage in such action changes the process of decision-making (Bruce et al., 2012).

Finally, there were differences in the hierarchical levels of the verbal reports. In the film-based condition, participants mentioned significantly more often concepts referring to their team members. In contrast, more concepts referring to the opponents were generated in the *in situ* condition. In the *in situ* condition, participants spent more time fixating on the attacker, impairing their perception of the blockers. This finding provides support for the perspective of attuning to specific affordances, which is dependent on the specific context of performance (Anson, Elliott & Davids, 2005; Passos et al., 2008). In fact, it has been demonstrated that different task constraints rely on divergent perceptual-cognitive processes (Bruce et al., 2012; Dicks et al., 2010; Mann et al., 2010). In this case, the possibility of actually intercepting the ball may explain why the participants referred more often to the opponents under the *in situ* condition.

In sum, it has been proposed that film-based studies and live-action research generate different measures of perceptual expertise (Mann et al.,

2007; Williams et al., 2011). In our study, differences across experimental conditions were shown for both visual search strategies and verbal reports of thinking. However, it should be acknowledged that notably no differences emerged on a number of variables such as the number of gaze fixations and fixation locations, as well as the number of verbalized condition concepts. Furthermore, the slightly elevated perspective through which the participants view the film footage may influence our findings, but it was required to produce a good viewing angle. In real-life situations, players can move their heads and bodies to better observe certain details of the surroundings, but a camera film is static. In this case, filming from a regular perspective would occlude relevant cues.

Although our data are exploratory, they demonstrate that the mechanisms underpinning skilled decision-making in sports may differ to some degree between film-based and *in situ* conditions, in line with previous research (Bruce et al., 2012; Button et al., 2011; Dicks et al., 2010). Moreover, these differences exist even when using extremely similar tasks and standardized experimental procedures. It is suggested that different image size and action possibilities afforded by each condition may have emerged as core components in explaining such differences. Therefore, it is strongly suggested that in future researchers explore the nature and magnitude of such differences.

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IV. Considerações Finais

Considerações finais

O objetivo geral da presente dissertação consistiu em indagar os mecanismos subjacentes ao processo de tomada de decisão (TD) em voleibol feminino, nomeadamente nas ações defensivas, em tarefa e contexto representativos da situação de jogo. Num primeiro momento, este propósito decorreu do reconhecimento do papel nuclear que a TD assume para a performance de elevado nível no desporto (Dicks, Button & Davids, 2010; Williams, 2009). Por seu turno, a utilização de tarefas representativas do jogo procurou respeitar a ecologia situacional do contexto real de prática (Araújo, Davids & Passos, 2007; Brunswik, 1955), permitindo uma maior transferência dos resultados da pesquisa para o âmbito da prática. Mais se acrescenta da pertinência de aplicação do estudo no voleibol feminino, dada a escassez de estudos sobre a TD nesta vertente. Em particular, afigura-se relevante compreender como se processa a TD das jogadoras num contexto defensivo, pelo peso que estas ações assumem no resultado final do jogo (Palao, Manzanares & Ortega, 2009).

Em função deste propósito global, foram delineados objetivos específicos visando responder a questões parciais, concorrentes na compreensão do fenómeno. Nomeadamente, num primeiro objetivo, procurou-se investigar o efeito da perícia sobre os comportamentos visuais e relatos verbais das jogadoras. Neste sentido, utilizou-se um sistema de seguimento da visão central, aliado à recolha de relatos verbais retrospectivos imediatos. Pese embora tal propósito seja comum neste tipo de investigação, importa considerar o facto do grau de representatividade da tarefa ter sido considerado no presente estudo, recorrendo-se a tarefas representativas do jogo, dado que a perícia é específica da tarefa e do contexto (Abernethy, Baker & Côté, 2005; Williams, Ward, Ward & Smeeton, 2008).

Um segundo objetivo específico consistiu em explorar as estratégias visuais utilizadas pelas jogadoras e os relatos verbais que produziam em ações defensivas, num contexto representativo do jogo. Os métodos de seguimento

visual e de recolha de relatos verbais são amplamente utilizados na investigação em TD (Mann, Coombes, Mousseau & Janelle, 2011; Williams & Ericsson, 2005), mas raramente são usados num mesmo experimento (para exceções, consultar McRobert, Ward, Eccles & Williams, 2011 e Roca, Ford, McRobert & Williams, 2011).

Finalmente, visou-se verificar se os processos de busca visual e os pensamentos verbalizados associados à TD na experimentação *in situ* diferem dos que decorrem da experimentação laboratorial, para tarefas equivalentes. Com efeito, a investigação tem vindo a sugerir que os processos percetivo-decisionais divergem consoante as condições experimentais (Button, Dicks, Haines, Barker & Davids, 2011; Williams, Ford, Eccles & Ward, 2011), sendo que a natureza e a magnitude dessas diferenças requerem uma exploração mais aprofundada.

Com o intuito de responder aos objetivos da dissertação foram realizados três estudos empíricos. O primeiro estudo consistiu em investigar o processo de TD numa condição de projeção de vídeo, diferenciando as jogadoras em função do respetivo nível de perícia. Recorrendo a um protocolo similar ao de Baker, Côté e Abernethy (2003), um painel de cinco treinadores peritos classificou as participantes com base numa avaliação das suas capacidades decisionais, dividindo-as em dois grupos: peritas e não-peritas. Os treinadores eram conhecedores das jogadoras e do seu nível de jogo e a taxa de acordo foi superior a 85%. Deste modo, quinze voleibolistas, divididas em dois grupos (peritas e não-peritas), participaram numa tarefa simulada de ações defensivas. As participantes visualizavam sequências em vídeo de cenários de jogo construídos previamente, posicionando-se na zona defensiva 6, próximas da linha final, com possibilidade de efetuarem deslocamentos e movimentos de ajuste sempre que necessário, como se procurassem interceptar a bola. O seu comportamento ocular foi registado por um sistema de seguimento da visão central (Applied Science Laboratories 3000 MobileEye™ registration system; Bedford, MA, USA), tendo sido recolhidos relatos verbais retrospectivos imediatos após cada cenário. Em síntese, os resultados

mostraram que as jogadoras peritas produziram fixações oculares de maior duração, exibindo uma tendência para estas serem em menor número e orientadas para um número mais restrito de locais. Por outro lado, fixaram o seu olhar durante mais tempo em espaços funcionais, fazendo um maior uso da visão periférica. Por último, as jogadoras peritas geraram mais conceitos de condição e com superior nível de sofisticação, relevando elevada sintonização calibrada⁹ aos constrangimentos colocados.

O segundo estudo seguiu uma lógica semelhante, mas foi conduzido *in situ*. Fizeram parte da amostra um grupo de vinte e sete jogadoras, expostas a cenários de jogo equivalentes aos do primeiro estudo, mas apresentados em condição de terreno. Foram recolhidos dados relativos aos movimentos oculares, bem como relatos verbais retrospectivos imediatos. A liberdade de ação foi expandida, na medida em que as jogadoras tinham a possibilidade de se moverem no campo e de intercetarem a bola (salvo algumas exceções devidamente assinaladas). Em contraste com o estudo precedente, as jogadoras peritas exibiram mais comportamentos oculares com pendor exploratório, denotando mais fixações para um maior número de locais, com tendência para estas serem de menor duração. De modo semelhante ao experimento de vídeo, as peritas despenderam mais tempo fixando em espaços funcionais e geraram mais conceitos de condição, igualmente com nível superior de sofisticação.

Conforme ficou patente, houve disparidades entre os dois estudos. No sentido de esclarecer o efeito do contexto de experimentação sobre os mecanismos subjacentes à TD, um terceiro estudo foi realizado, tendo-se utilizado os dois contextos experimentais. Recrutou-se um grupo de nove jogadoras com nível de perícia equivalente (elevado). Procurou-se, assim, explorar e compreender as possíveis semelhanças e diferenças procedentes do contexto experimental. Neste estudo, a condição de terreno promoveu fixações oculares mais prolongadas do que a condição de vídeo, com tendência para a realização de menor número de fixações. No que concerne à

⁹ Perceção calibrada significa que o sujeito percecionou adequadamente a situação e, adicionalmente, agiu em conformidade com as exigências situacionais (Mesquita, 2005).

percentagem de tempo de visualização para cada indicador, a condição de terreno suscitou maior tempo de fixação das jogadoras defensoras nas atacantes, enquanto a condição de vídeo potenciou a fixação em atacantes potenciais. No geral, os dois contextos promoveram percentagens de tempo de visualização semelhantes. No respeitante aos relatos verbais, a condição de terreno induziu níveis superiores de sofisticação (ou seja, mais adequados à situação e com superior nível de detalhes) e maior número de conceitos relacionados com os adversários.

Da súmula dos três estudos emergem alguns elementos relevantes para uma análise global. A comparação direta entre a experimentação *in situ* e a projeção de vídeo revelou um conjunto de diferenças significativas entre os dois contextos. De um modo global, o tamanho absoluto da imagem e a perceção da profundidade podem constituir uma explicação robusta para a generalidade das diferenças encontradas (Al-Abood, Davids, Bennett, Ashford & Marin, 2002). O tamanho da imagem pode ser manipulado em contexto laboratorial, mas não alcançará o tamanho da imagem em condição real de prática, existindo sempre algum limite físico às dimensões da tela de projeção. Por outro lado, e enquanto a tecnologia tridimensional não emergir associada à pesquisa em comportamentos oculares, a dimensão profundidade resultará sempre adulterada.

Relativamente aos relatos verbais, o nível de sofisticação dos conceitos gerados foi superior na condição *in situ*. Com efeito, entende-se que este dado reflete uma perceção mais calibrada dos acoplamentos perceção-ação na condição de terreno (i.e. um maior alinhamento entre o que se percebe e a forma como se age), fruto da experiência específica das jogadoras neste contexto, a qual não ocorre na situação de projeção de vídeo. Suporta-se, desta forma, a natureza específica da performance (Abernethy et al., 2005; Ericsson & Lehmann, 1996; Passos, Araújo, Davids & Shuttleworth, 2008). As diferenças estenderam-se, ainda, aos níveis hierárquicos dos relatos verbais, que se centraram mais nos adversários na condição *in situ* e nos colegas de equipa na condição de vídeo. A condição de terreno, seja pela maior

dimensionalidade da imagem, seja pela responsabilidade de efetivamente se procurar defender a bola, induz uma maior focalização da atenção nos adversários, diminuindo a relação funcional com os colegas de equipa. Esta preocupação não ocorre nos estudos de projeção de vídeo, confirmando que a não-especificidade do contexto não é indutora dos acoplamentos percepção-ação que decorrem de situações reais de prática, enviesando concomitantemente os processos subjacentes à TD (Montagne, Bastin & Jacobs, 2008; Oliveira et al., 2009).

Não obstante as diferenças emergentes, o contexto de projeção de vídeo produziu alguns dados em clara consonância com a condição de terreno. Por exemplo, as diferenças no espaço de fixação foram reduzidas, havendo uma elevada semelhança no que concerne à maioria dos locais de fixação e à distribuição do tempo de fixação. A frequência de fixações e os espaços de fixação também foram semelhantes. Por outro lado, em ambos os contextos a quantidade de conceitos de condição produzidos afigurou-se equivalente. Poderá argumentar-se que, em níveis de participação desportiva perita, são os pormenores que diferenciam os bem-sucedidos dos demais. De acordo com esta lógica, as diferenças entre contextos de investigação (*in situ* versus laboratorial), embora não extensivos a todos os aspetos correlatos com a TD, poderão constituir-se como decisivas e altamente relevantes (Button et al., 2011).

Sobre o efeito da perícia, também se justifica tecer algumas considerações, uma vez que, no estudo de projeção de vídeo, as jogadoras peritas mantiveram fixações mais prolongadas, embora menos divergentes e em menor número (i.e., focando-se num número mais restrito de localizações). Estes resultados corroboram os encontrados por Piras, Lobietti e Squatrito (2010), num estudo realizado no voleibol masculino, embora avaliando ações de distribuição. Tal sugere a utilização de uma estratégia visual mais económica por parte dos peritos, atendendo apenas aos indicadores mais relevantes em cada contexto. No que concerne à distribuição temporal das fixações, as peritas despenderam mais tempo do que as não-peritas fixando

espaços funcionais entre jogadoras, revelando uma menor dependência da trajetória da bola. Todavia, resultados díspares foram obtidos no estudo *in situ*, porquanto as jogadoras peritas realizaram uma maior frequência de fixações para uma mais vasta quantidade de espaços, adotando uma estratégia menos económica e mais exploratória, em linha com o estudo de North, Williams, Hodges, Ward e Ericsson (2009), este no futebol. Admite-se que o tamanho da imagem possa contribuir para estas diferenças, algo que foi demonstrado por Al-Abood et al. (2002). Por outro lado, a condição experimental *in situ*, ao promover acoplamentos percepção-ação distintos dos verificados na condição de projeção de vídeo (e.g.: havendo uma possibilidade real de intercetar a bola), induz variações nos mecanismos de busca visual e nos processos de pensamento subjacentes à TD, como vem sendo demonstrado na literatura (Bruce, Farrow, Raynor & Mann, 2012; Dicks et al., 2010; Mann, Abernethy & Farrow 2010).

Relativamente aos dados obtidos através dos relatos verbais, os estudos de projeção de vídeo e *in situ* permitiram perceber que as peritas, quando comparadas com as não-peritas, geram um maior número de conceitos de condição e com maior nível de sofisticação, em conformidade com estudos realizados no beisebol (McPherson, 1993), ténis (McPherson & Kernodle, 2007) e voleibol (Araújo, Afonso & Mesquita, 2011). Daqui se infere que níveis de perícia superiores decorrem de uma melhor sintonização com os constrangimentos situacionais, bem como de uma maior profundidade da respetiva análise. Acresce que as peritas se focaram mais nas colegas de equipa do que as suas colegas não-peritas. Como nota a destacar, salienta-se que, *in situ*, as peritas focaram-se mais do que as não-peritas nas adversárias e não nas colegas de equipa, o que sugere que, em contextos mais próximos da realidade do jogo, existe uma maior focalização nas adversárias.

O cruzamento de dados relativos a estratégias visuais e relatos verbais em contextos diferenciados revelou ser de profundo interesse. Nomeadamente, os relatos verbais corroboraram alguns dados obtidos via seguimento ocular. A título ilustrativo, no terceiro experimento as jogadoras fixaram mais tempo as

atacantes adversárias do que as bloqueadoras na condição *in situ*. Nos seus relatos, produziram mais frases relacionadas com as atacantes, em congruência com a informação recolhida utilizando a visão central. Sucedeu precisamente o inverso no contexto de projeção de vídeo. Confirma-se, assim, que a conjugação de métodos de seguimento visual com métodos de recolha de relatos verbais se afigura profícua na demanda de um conhecimento mais aprofundado acerca do modo como se processa a TD em ação (Ericsson & Williams, 2007; McPherson & Vickers, 2004). Até porque o recurso a contextos mais ou menos afastados da realidade do jogo geram relações diferenciadas, tanto entre os relatos verbais como nas estratégias visuais utilizadas, devendo este aspeto ser considerado pela investigação científica.

Em suma, o presente estudo evidenciou que os experimentos laboratoriais produzem resultados distintos dos experimentos *in situ*, para tarefas comparáveis. Nomeadamente, verificam-se divergências no que concerne à duração média das fixações oculares, percentagem de fixação em alguns locais de interesse, nível de sofisticação dos relatos verbais e níveis hierárquicos desses relatos. Todavia, existem resultados que não são adulterados pela mudança de contexto experimental, como, por exemplo, a frequência de fixações e a quantidade de espaços fixados, a distribuição temporal de fixação na maioria das localizações, e quantidade de conceitos produzidos verbalmente. Conclui-se que a utilização de experimentos laboratoriais fornece alguma informação passível de generalização para condições reais de prática, mas que relativamente a outros tipos de informação produz uma deturpação que inibe a sua transferência para contextos de prática efetiva. Os resultados sugerem afigurar-se conveniente que as pesquisas nesta área incorporem desenhos representativos da tarefa e que, se possível, sejam conduzidas no terreno, seguindo a abordagem proposta por Brunswik (1995) e em linha com as propostas de Bruce et al. (2012), Ericsson e Ward (2007) e McPherson e Kernodle (2003).

Considerações finais

O presente estudo revelou também que, independentemente do contexto de realização do experimento, a recolha de dados por diferentes vias (no caso, comportamento ocular e relatos verbais) possibilita a construção duma perspetiva mais completa dos processos que subjazem à TD. Todavia, os relatos verbais fizeram emergir algo muito claro: uma acentuada tendência para relatar apenas os indicadores de jogo situados temporalmente no final da sequência. Deste modo, a recolha de relatos verbais tende a enfatizar os indicadores relevantes na parte final das sequências ou jogadas e permite compreender a importância que as jogadoras atribuem a cada indicador de jogo. Porém, regra geral, desconsideram os indicadores observados mais precocemente na sequência e que são suscetíveis de condicionar as estratégias de observação e de previsão. Neste sentido, os relatos verbais não dispensam a utilização de seguimento ocular para estudar os processos decisoriais.

Por último, confirma-se que o nível de perícia interfere com os processos perceptivo-decisionais. As jogadoras peritas demonstram uma sintonização mais calibrada aos constrangimentos situacionais, para além de revelarem um conhecimento mais profundo da situação, estando de acordo com as perspetivas vigentes (Abernethy, Gill, Parks & Packer, 2001; Behrmann & Ewell, 2003; McPherson & Kernodle, 2007). Todavia, a natureza e a magnitude das diferenças modifica-se parcialmente sob influência das condições experimentais, o que havia sido já intuído em estudos prévios (Bruce et al., 2012; Jackson, Warren & Abernethy, 2006; Mann et al., 2010).

Limitações e sugestões para futuros estudos

À semelhança de outros estudos de natureza científica, a pesquisa conduzida no âmbito da presente dissertação apresenta limitações que passamos a mencionar. Reconhecidamente, uma das limitações dos três estudos realizados foi a ausência de recolha de dados relativos à performance. A possibilidade de realizar uma ação defensiva integral, sem qualquer limitação, integrando avaliação estatística da sua eficácia, tornaria esta pesquisa mais representativa da condição real de prática do jogo de voleibol.

No entanto, este pressuposto, para ser cumprido, necessitaria de uma evolução tecnológica dos dispositivos de seguimento ocular, nomeadamente permitindo uma maior robustez e durabilidade da calibração face a ações de impacto (e.g.: saltos e quedas). Conforme referido anteriormente, a utilização do sistema de seguimento visual inibe ações como as quedas, os saltos, entre outras, constringendo negativamente, em parte, a ação motora das participantes. Até porque a especificidade dos acoplamentos entre percepção e ação (Gibson, 1979; Newell, 1986; Hristovski, Davids & Araújo, 2009), induz modificações no processo perceptivo e, concomitantemente, no processo decisional.

Adicionalmente, como já referido, a recolha de relatos verbais e o seguimento ocular proporcionam uma relevante janela de acesso aos processos atencionais, mas existem duas dimensões adicionais na TD que são de relevante importância e cuja análise em futuras pesquisas se impõe. Referimo-nos à memória e à antecipação. Está disponível um robusto corpo de investigação científica nestes dois campos, faltando integrá-los no paradigma proposto nesta dissertação, ou seja, utilizando desenhos representativos da tarefa em condições (preferencialmente) de terreno e cruzando múltiplos métodos na recolha de dados. Contudo, tal implicará a continuidade dos cenários de prática avaliados, pois a emergência do pensamento estratégico decorre da sequenciação ou encadeamento de eventos; ou seja, as ações e cenários fazem parte dum todo coerente e histórico e não devem, por isso, ser tratados como eventos isolados. Com efeito, as ações correntes influenciam as ações futuras (Gold & Shadlen, 2007), sendo isso particularmente evidente nos JD (Lames & McGarry, 2007). Assim, parece justificar-se que esta questão assuma uma notória centralidade em futuras pesquisas, na medida em que o pensamento estratégico implica a memória de eventos passados e a previsão de eventos futuros, condicionando as estratégias de procura de informação..

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