Psychology of Sport and Exercise 14 (2013) 211–219

Contents lists available at SciVerse ScienceDirect

Psychology of Sport and Exercise

journal homepage: www.elsevier.com/locate/psychsport

Review

Expertise effects on decision-making in sport are constrained by requisite response behaviours – A meta-analysis

B. Travassos [a,b,*], D. Araújo [c,d], K. Davids [e], K. O'Hara [a], J. Leitão [b,f], A. Cortinhas [f]

[a] Department of Sport Sciences, University of Beira Interior, Rua Marquês d'Ávila e Bolama, 6201-001 Covilhã, Portugal
[b] CIDESD – Research Center in Sports, Health Sciences and Human Development, Portugal
[c] Faculty of Human Kinetics, Technical University of Lisbon, Estrada da Costa, 1495-688 Cruz Quebrada, Portugal
[d] CIPER – Interdisciplinary Centre for the Study of Human Performance, Portugal
[e] School of Human Movement Studies, Queensland University of Technology, Victoria Park Road, Kelvin Grove, QLD 4059, Australia
[f] Department of Sport Sciences Exercise and Health, University of Trás-os-Montes e Alto Douro, 5001-081 Vila Real, Portugal

ARTICLE INFO

Article history:
Received 13 February 2012
Received in revised form
5 November 2012
Accepted 6 November 2012
Available online 12 November 2012

Keywords:
Decision-making
Expertise effects
Movement responses
Research methods
Representative tasks

ABSTRACT

Objectives: A quantitative review of the effects of requisite responses and methods of stimulus presentation for assessing decision-making expertise in sport was undertaken.
Design: An electronic literature search was conducted in the online databases: SPORTDiscus with Full Text and ISI Web Knowledge All Databases. Articles for analysis were selected according to prior defined criteria.
Methods: We considered 111 effect sizes in studies involving 882 expert and non-expert participants. Effect sizes were calculated for six common protocols for measures responses: verbalized knowledge, eye movement measures, decision time, response accuracy, movement accuracy, and movement time. Two moderator variables were also considered to assess effects of research protocols on the dependent variables: "the requisite response" and "stimulus presentation". A random effect model was used to calculate effect sizes.
Results: Analysis of moderator variables suggested that expertise effects were more apparent for "requisite responses" when participants were required to actually perform sporting actions and for "stimulus presentation" under *in situ* task constraints than for other conditions.
Conclusions: Future empirical work on expertise and decision-making needs to consider task representativeness in considering requisite responses of participants in simulating performance environment conditions. Use of representative task constraints with performers required to perform sport actions in *in situ* conditions appeared the most functional empirical protocols to enhance validity of data.

Decision-making capabilities have been reported to play a significant role on goal achievement during sports performance (Araújo, Davids, & Hristovski, 2006; Bar-Eli, Pessner, & Raab, 2011). Decision-making can be broadly defined as the capability of individuals to select functional actions to achieve a specific task goal from a number of action possibilities (Hastie, 2001).

Over time, different approaches have been developed to study decision-making in the specific context of sport. This plural view of decision-making in sport has revealed some differences in the nature of the decisions (i.e., deterministic or probabilistic) or on the temporal character of decisions (i.e., static or dynamic), with clear implications for accumulated knowledge and for sport psychologists (Bar-Eli & Raab, 2009). Deterministic and static rational approaches to decision-making in sport have attempted to analyse how athletes might mentally calculate the ratio between gains and losses before selecting a response. This approach focused on the study of the gaps between hypothesized normative and actual options, when athletes solve a problem in a sport context (Bar-Eli et al., 2011). However, recently, it has been proposed that future research on decision-making in sport needs to consider a more dynamic perspective considering both cognition and action (Bar-Eli & Raab, 2009). Particularly in sport, behavioural decision-making is a complex, temporally extended process, and it makes little sense to consider a putative optimal decision prior to, or independently of, the behavioural expression of that decision during performance (Araújo et al., 2006; Beer, 2003).

* Corresponding author. Sport Sciences Department, University of Beira Interior, Convento de Sto. António, 6201-001 Covilhã, Portugal.
E-mail addresses: bruno.travassos@ubi.pt, brunotravassos@hotmail.com (B. Travassos).

1469-0292/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.psychsport.2012.11.002

One of the critical challenges in the study of decision-making expertise concerns the ability to design experimental task constraints and conditions that capture the essential characteristics of expertise as expressed in specific sport performance contexts (Ericsson & Ward, 2007; Hodges, Huys, & Starkes, 2007). To evaluate the effect of expertise on decision-making in sport, research protocols need to capture the perceptual-cognitive factors that guide performers decisions, but also the functional patterns of behaviour that emerge during performance (Davids & Araújo, 2010). That is, studies need to consider how players behaviourally interact with different features of the environment during successful performance.

Although the methods used to study decision-making have changed considerably over the years in the quest to provide more sensitive and reliable measures of expert/novice differences in sport (Hodges et al., 2007), some research approaches lack sensitivity and reliability with respect to the performance environment (Williams & Ward, 2007). A major issue is that specific protocols to measure decision-making have often failed to reproduce representative performance conditions allowing participants to (re) produce the behaviours that underpin expert–novice differences (Ericsson & Ward, 2007; Williams & Ward, 2007).

Recently Mann, Williams, Ward, and Janelle (2007) provided a meta-analysis to investigate the perceptual-cognitive expertise in sport. In general they observed that perceptual-cognitive strategies are task dependent, i.e. that methodological developments influence expert advantage on perceptual-cognitive skills. The results of Mann et al. (2007) support the argument that a specific performance environment is assumed as one of the most valid settings for assessing expertise on perceptual-cognitive skills due to the fact that performers are using the same perceptual variables to guide their behaviours. However, the study by Mann et al. (2007) did not consider the reciprocal influence of the *type of action* required by participants in studies of expertise.

In this line of reasoning, a study of association football goalkeepers by Dicks, Button, and Davids (2010) reported significant differences in the patterns of gaze emerging under *in situ* performance conditions requiring a verbal response, a simplified movement or ball interception by participants. The goalkeepers in their study tended to fixate earlier and for longer duration on the ball's location when an interceptive movement was required. This observation was justified by the fact that, when performers were required to intercept penalty kicks, they needed to pick up egocentric information (i.e., the properties of an object relative to the performer), instead of allocentric information (i.e., the properties of objects perceived independently of the performer) (Dicks et al., 2010; Van der Kamp, Rivas, Van Doorn, & Savelsbergh, 2008).

Based on the work of Pinder and colleagues (Pinder, Davids, Renshaw, & Araújo, 2011), to capture differences in expertise and decision-making in sport, a key influence is not only the type of information (i.e., perceptual cues) used in experimental designs, but also the effects of the type of behavioural response required by the participant (e.g., verbal response, a simplified movement or an interceptive task). The challenge for sport scientists is to design empirical task constraints which accurately sample the information and actions required for performance in specific performance contexts (for implications in sport psychology see Pinder et al., 2011).

These theoretical insights raise important concerns over the specific task constraints used in previous studies of expertise and decision-making in sport, related to: (i) the informational constraints of prevalent experimental designs on decision-making behaviours (use of still images, and video film of performance, or *in situ* task constraints); (ii) requisite responses of participants (verbal reports, micro-movements, performance of sport actions);and (iii), variables used currently to measure expert–novice differences. An important task is to understand whether methodological differences in stimulus presentation and, particularly, in requisite behavioural responses of participants, may have influenced research outcomes in analysis of expertise effects on decision-making. Using meta-analytic methods to cumulate individual research findings, here we extended previous research by evaluating the influence of stimulus presentation methods and requisite responses as potential moderators on the experimental outcomes reported in the literature on expertise and decision-making performance in sport.

Method

Literature search

An electronic literature search was conducted for articles published in the past 15 years, between January 1995 to March 2010, on the online databases SPORTDiscus with Full Text and ISI Web Knowledge All Databases. Combinations of the following keywords were used: "expert/ise", "decision-making", "sport", "performance", "judgement" and "cognition", a total of 1287 were analysed (1072 from Sport Discus, 373 from ISI Web Knowledge excluding 158 that were the same in both databases). The experimental protocol was approved by the local university institution's ethics guidelines.

Selection criteria

According the proposal of Simmons, Nelson, and Simonsohn (2011) selection criteria and variables for analysis have been defined prior to electronic search. Eligible manuscripts considered in this study contained an abstract written in English. We excluded abstracts from dissertations, book chapters, unpublished data and conference proceedings because of the possibility that the data had not undergone a substantial external peer-reviewed process. Peer-reviewed studies were included according to the following criteria: a) the study included a sport performance context; b) there was an expert/non-expert comparison; c) the study presented information of experience and playing level of participants (to be included in the analysis, participants categorized as expert needed to demonstrate more than 10 years of deliberate practice (Ericsson & Ward, 2007). If not reported we considered for analysis studies in which expert participants performed in senior high level championships); d) the study measured decision-making and used it as a key element in the discussion (because previous studies revealed that the task goal and instructions can change performers' perceptions (Cañal-Bruland & Van der Kamp, 2009) and action (Cordovil, Araujo, Davids, & Gouveia, 2009); and e), the study presented data (*M* and SD, *t* value, exact *p*-value, or a simple effect *F* ratio) in order to compute an effect size (Borenstein, Hedges, Higgins, & Rothstein, 2009).

The first author coded the studies according to the selection criteria and the fourth author coded a random sample of twenty studies to examine coding reliability (Hagger, 2006). We observed 100% of agreement in inclusion/exclusion of studies.

Computation and analysis of effect sizes

Effect sizes (ESs) for each identified variable were standardized by calculating the standard differences in means (Borenstein et al., 2009; Hedges & Olkin, 1985). Effect sizes were corrected to assure independence according to proposals by Hedges and Olkin (1985). Considering differences in the samples, in the type of measures and the different methods used in each study, a random effect model was used (Hagger, 2006; Hedges & Olkin, 1985).

Based on previous research (Mann et al., 2007; Williams & Ericsson, 2005), for analysis of statistical effects, six dependent variables for grouping effect sizes were considered in order to ensure that underlying perceptual-cognitive mechanisms sustained decision-making in sport. These included: i) verbalized knowledge (VK) – declarative description that performers used to justify their decisions; ii) eye movement measures (EMM) – different measures of performers' visual fixation of specific informational sources. Here, the number of fixations, fixation duration, fixation order and the number of areas fixated were considered; iii) decision time (DT) – the elapsed time from the stimulus presentation to the participants response; iv) response accuracy (RA) – frequency of correct decisions based on prior rational evaluations by expert coaches; v) movement accuracy (MA) – frequency of functional behaviours performed to successfully achieve specific performance goals; and vi), movement time (MT) – the time duration required to perform a specific movement to achieve performance goals.

Heterogeneity between effect sizes was analysed by applying a Q-test. The Q value represents the total of variance among all the effect sizes. A significant Q value reveals the level of heterogeneity in a data set. A non-significant Q value reveals similarity of the effect across studies, i.e., homogeneity. Also, in order to test the moderator variables, $Q_{(\mathrm{bet})}$ values were calculated. A significant effect indicated that the moderator variable contributed to the variance among effect sizes. The $Q_{(\mathrm{Within})}$ measures the variance of a dependent variable. A significant $Q_{(\mathrm{Within})}$ value reveals the level of heterogeneity for that variable (Borenstein et al., 2009).

To estimate the influence of publication bias on the effect size of each dependent variable (i.e., the influence of the studies not considered in calculating the obtained effect sizes), a fail-safe n was calculated in order to estimate the number of studies averaging null results (Hagger, 2006; Rosenthal, 1991). A high value of a fail-safe n signifies a high level of consistency in obtained results. The entire data set was transformed in Comprehensive Meta-Analysis software package, 2008 (BioStat, Englewood, New Jersey).

Moderator variables

Based on the theoretical framework proposed by Williams and Ericsson (2005) to capture perceptual-cognitive expertise in sport and to evaluate the extent to which effects of expertise in decision-making were influenced by different research task constraints, two potential moderator variables were examined: "requisite response" and "stimulus presentation". Three sub-conditions were considered for "requisite response" according to the most prevalent conditions in the literature: i) *verbal reports* (verbal description of concurrent and retrospective thoughts about performance environment), ii) *micro-movements* (brief motor response such as a button press, joystick movement or brief directional movement), iii) *sport performance* (motor actions in a sport context to achieve a sport task goal). For "stimulus presentation", three sub-conditions were identified according to the most prevalent approaches in the literature: i) *slide images* (two dimensional static images), ii) *video presentations* (two dimensional video presentations of sport scenes), iii) *in situ* (specific performance contexts).

Results

After eliminating studies that did not achieve the inclusion criteria, thirty-one papers generating 111 effect sizes were considered (see Table 1), involving 882 participants, of which 47.17% ($N = 416$) were considered as expert and 52.83% ($N = 466$) were considered as non-expert, to categorize effect sizes. (N.B.: Some studies meeting most of the selection criteria were excluded from analysis because they used a different type of "stimulus presentation" (e.g. computer simulation), or used different dependent variables for expertise comparison (e.g., brain activity)) Each dependent variable was analysed independently and statistically significant results in a heterogeneity test were observed for eye movement measures, decision time and response accuracy variables ($Q_{(t)} = 46.22$, $p < 0.001$, $Q_{(t)} = 54.76$, $p < 0.001$ and $Q_{(t)} = 179.73$, $p < 0.001$, respectively).

Verbalized knowledge (VK)

The 12 effect sizes of VK revealed a significant effect size ES = 1.31, 95% CI [1.00, 1.63], with $Z = 8.16$, $p < 0.001$. The Q-test for heterogeneity revealed non-significant values $Q_{(t)}$ (11) = 4.13, $p > 0.05$ i.e., homogeneity. The fail-safe n was 197, signifying that approximately 200 studies averaging null results would be needed to modify the significance of the current effect size for the VK variable.

No studies assessing verbal report measures of athletes were found to use a *sport performance* condition for the "requisite responses" moderator variable, nor an *in situ* condition for the "stimulus presentation" moderator variable. The overall estimate of the effect size between groups ($Q_{(\mathrm{bet})}$) was calculated with statistically non-significant outcomes ($p > 0.05$). This evaluation indicated that none of the proposed moderating variables were moderating for VK (see Table 2).

Eye movement measures (EMM)

The 25 effect sizes in which EMM were identified revealed a significant effect size ES = 1.21, 95% CI [0.91, 1.51], with $Z = 7.89$, $p < 0.001$. The Q-test for heterogeneity revealed significant values $Q_{(t)}$ (24) = 46.22, $p < 0.01$. The fail-safe n was 760, signifying that 760 studies averaging null results would be needed to modify the significance of the current effect size for the EMM variable.

For "requisite response", the *verbal reports* condition was not found in any study using EMM. Despite of heterogeneity on Q-test, the overall estimate of the effect size between groups ($Q_{(\mathrm{bet})}$) was calculated with non-significant results ($p > 0.05$). Therefore none of the proposed moderator variables were deemed to be influences on EMM (see Table 2). However, interestingly the Q-test for heterogeneity ($Q_{(\mathrm{within})}$) revealed homogeneity just for *sport performance* condition in the moderating variable "requisite response" $Q_{(\mathrm{within})}$ (15) = 12.38, $p > 0.05$ and for *in situ* condition in the moderating variable "stimulus presentation" $Q_{(\mathrm{within})}$ (6) = 6.01, $p > 0.05$. The other conditions revealed heterogeneity in the results (see Table 3). (Note: the *slide* condition in the moderating variable "stimulus presentation" only revealed homogeneity but was identified in only one study that included this condition.)

Decision time (DT)

The 23 effect sizes in which DT was identified revealed a significant effect size ES = 1.39, 95% CI [1.10–1.67], with $Z = 9.57$, $p < 0.001$. The Q-test for heterogeneity revealed significant values $Q_{(t)}$ (22) = 54.76, $p < 0.001$, i.e., heterogeneity. The fail-safe n was 1334, signifying that approximately 1300 studies averaging null results would be needed to modify the significance of the current effect size for the DT variable.

The overall estimate of the effect size between groups was calculated for each of the moderating variables with significant results for "requisite response" $Q_{(\mathrm{bet})}$ (2) = 13, $p < 0.001$ but not for "stimulus presentation" $Q_{(\mathrm{bet})}$ (2) = 0.71, $p > 0.05$. Thus, "requisite

Table 1
List of all the publications used with the variables considered for analysis and the correspondent statistical measures.

Study	Statistics for each study							Sample size	
	Variable	Effect size	Standard error	Lower limit	Upper limit	*Z*-value	*p*-Value	Exp	Nov
Abernethy, Baker, and Cotê (2005)									
	RA	0.42	0.92	(1.39)	2.23	0.46	0.65	3	2
	RA	0.46	0.77	(1.06)	1.98	0.59	0.55	4	3
	RA	0.77	0.59	(0.39)	1.93	1.31	0.19	8	5
Abernethy and Neal (1999)									
	DT	2.67	0.57	1.54	3.79	4.65	0.00	11	12
Bertrand and Thullier (2009)									
	EMM	0.97	0.39	0.20	1.74	2.47	0.01	15	14
	RA	1.07	0.40	0.29	1.85	2.70	0.01	15	14
Del Villar, Gonzalez, Iglesias, Moreno, and Cervello (2007)									
	RA	3.56	0.93	1.74	5.38	3.83	0.00	6	6
	RA	1.90	0.70	0.53	3.26	2.73	0.01	6	6
	RA	2.01	0.71	0.62	3.40	2.84	0.00	6	6
	RA	1.73	0.68	0.40	3.05	2.55	0.01	6	6
Fontana, Mazzardo, Mokgothu, Furtado, and Gallagher (2009)									
	RA	1.49	0.40	0.71	2.27	3.72	0.00	16	16
	DT	0.93	0.37	0.20	1.66	2.50	0.01	16	16
González, Arroyo, Domínguez, Gallego, and Alvarez (2009)									
	RA	5.50	1.26	3.02	7.97	4.36	0.00	6	6
	MA	3.33	0.89	1.58	5.08	3.74	0.00	6	6
	MA	2.25	0.74	0.80	3.69	3.05	0.00	6	6
	MA	2.85	0.82	1.24	4.45	3.47	0.00	6	6
Gygax, Wagner-Egger, Parris, Seiler, and Hauert (2008)									
	VK	1.27	0.52	0.26	2.29	2.46	0.01	9	9
	VK	1.42	0.53	0.39	2.46	2.70	0.01	9	9
Helsen and Starkes (1999)									
	DT	1.17	0.41	0.37	1.97	2.86	0.00	14	14
	EMM	1.22	0.41	0.42	2.03	2.97	0.00	14	14
	DT	0.98	0.40	0.19	1.76	2.44	0.01	14	14
	MT	1.52	0.43	0.68	2.36	3.54	0.00	14	14
	EMM	1.79	0.45	0.92	2.67	4.01	0.00	14	14
	EMM	1.01	0.40	0.22	1.80	2.51	0.01	14	14
	EMM	1.38	0.42	0.55	2.20	3.28	0.00	14	14
	RA	4.89	0.75	3.41	6.37	6.48	0.00	14	14
	RA	6.18	0.91	4.40	7.96	6.80	0.00	14	14
Huber (1997)									
	VK	1.77	0.83	0.14	3.41	2.13	0.03	4	4
	VK	0.82	0.74	(0.63)	2.26	1.11	0.27	4	4
	VK	1.67	0.82	0.06	3.27	2.03	0.04	4	4
	VK	1.98	0.86	0.29	3.67	2.29	0.02	4	4
	VK	1.77	0.83	0.13	3.40	2.12	0.03	4	4
	VK	1.71	0.83	0.09	3.33	2.07	0.04	4	4
Jackson, Warren, and Abernethy (2006)									
	RA	1.19	0.41	0.38	1.99	2.90	0.00	14	14
Jackson and Mogan (2007)									
	RA	1.29	0.45	0.41	2.17	2.87	0.00	13	11
	VK	1.65	0.47	0.73	2.58	3.49	0.00	13	11
Kioumourtzoglou, Kourtessis, Michalopoulou, and Derri (1998)									
	RA	1.48	0.42	0.66	2.30	3.53	0.00	12	18
	VK	0.97	0.39	0.20	1.74	2.46	0.01	12	18
	VK	1.33	0.41	0.52	2.13	3.24	0.00	12	18
	DT	0.76	0.39	0.01	1.52	1.97	0.05	12	18
	DT	0.74	0.36	0.02	1.45	2.02	0.04	13	21
	RA	3.26	0.53	2.22	4.30	6.15	0.00	13	21
	RA	1.16	0.34	0.49	1.83	3.40	0.00	19	21
	DT	0.98	0.34	0.33	1.64	2.93	0.00	19	21
Kioumourtzoglou, Kourtessis, Michalopoulou, and Derri (1997)									
	RA	1.16	0.34	0.49	1.83	3.40	0.00	19	21
	DT	0.98	0.34	0.33	1.64	2.93	0.00	19	21

Table 1 (*continued*)

Study	Statistics for each study							Sample size	
	Variable	Effect size	Standard error	Lower limit	Upper limit	*Z*-value	*p*-Value	Exp	Nov
Lee, Kim, and Seung-Ha (2009)									
	EMM	1.55	0.72	0.14	2.97	2.15	0.03	5	5
	EMM	0.70	0.65	(0.58)	1.97	1.07	0.28	5	5
Martell and Vickers (2004)									
	EMM	0.98	0.61	(0.22)	2.17	1.60	0.11	6	6
	EMM	0.36	0.58	(0.78)	1.50	0.61	0.54	6	6
McMorris and Graydon (1996)									
	RA	3.34	0.69	1.98	4.70	4.83	0.00	10	10
	DT	4.25	0.81	2.67	5.83	5.26	0.00	10	10
Nakamoto and Mori (2008)									
	DT	1.70	0.40	0.92	2.48	4.28	0.00	24	13
Nielsen and Sue (2001)									
	RA	3.51	0.92	1.71	5.31	3.82	0.00	6	6
	MA	7.47	1.63	4.27	10.66	4.58	0.00	6	6
	RA	3.17	0.87	1.47	4.87	3.65	0.00	6	6
	MA	3.71	0.95	1.84	5.57	3.89	0.00	6	6
Paull and Glencross (1997)									
	DT	1.22	0.40	0.44	2.00	3.07	0.00	15	15
	RA	1.19	0.40	0.42	1.97	3.01	0.00	15	15
	DT	2.81	0.51	1.80	3.82	5.46	0.00	15	15
	DT	2.88	0.52	1.86	3.90	5.52	0.00	15	15
Petit and Ripoll (2008)									
	DT	0.92	0.29	0.36	1.48	3.20	0.00	26	28
Reina, Moreno, and Sanz (2007)									
	EMM	1.57	0.67	0.26	2.88	2.35	0.02	5	7
	EMM	2.52	0.78	0.99	4.05	3.24	0.00	5	7
	EMM	1.61	0.67	0.29	2.92	2.39	0.02	5	7
	EMM	1.71	0.68	0.38	3.05	2.51	0.01	5	7
	EMM	1.95	0.71	0.56	3.33	2.75	0.01	5	7
	EMM	2.01	0.72	0.61	3.41	2.81	0.00	5	7
	DT	1.88	0.70	0.51	3.25	2.69	0.01	5	7
	MT	1.65	0.68	0.33	2.97	2.44	0.01	5	7
	DT	1.65	0.68	0.33	2.98	2.45	0.01	5	7
Ripoll, Kerlirzin, Stein, and Reine (1995)									
	EMM	(2.45)	0.76	(3.95)	(0.96)	(3.21)	0.00	6	6
	EMM	2.07	0.72	0.67	3.48	2.89	0.00	6	6
	EMM	2.08	0.72	0.68	3.49	2.90	0.00	6	6
	DT	0.51	0.59	(0.64)	1.66	0.87	0.38	6	6
	RA	0.63	0.59	(0.53)	1.79	1.06	0.28	6	6
Rowe, Horswill, Kronvall-Parkinson, Poulter, and McKenna (2009)									
	RA	4.03	0.42	3.22	4.85	9.68	0	18	62
Savelsbergh, Williams, Van Der Kamp, and Ward (2002)									
	RA	1.13	0.58	0.01	2.26	1.97	0.05	7	7
	RA	1.26	0.59	0.12	2.41	2.16	0.03	7	7
	RA	1.32	0.59	0.16	2.47	2.24	0.03	7	7
	RA	1.29	0.59	0.14	2.44	2.19	0.03	7	7
	RA	1.51	0.61	0.32	2.70	2.50	0.01	7	7
	EMM	1.92	0.65	0.66	3.19	2.98	0.00	7	7
	EMM	3.03	0.78	1.50	4.57	3.87	0.00	7	7
	EMM	1.38	0.59	0.21	2.55	2.32	0.02	7	7
Shim, Carlton, Chow, and Chae (2005)									
	RA	1.86	0.48	0.92	2.79	3.88	0.00	13	12
Ste-Marie (1999)									
	RA	1.16	0.44	0.29	2.02	2.63	0.01	12	12
Tenenbaum, Sar-El, and Bar-Eli (2000)									
	RA	0.50	0.45	(0.39)	1.39	1.10	0.27	10	10
	RA	0.22	0.45	(0.66)	1.10	0.49	0.62	10	10
	RA	0.72	0.46	(0.18)	1.62	1.56	0.12	10	10

(*continued on next page*)

Table 1 (*continued*)

Study	Statistics for each study							Sample size	
	Variable	Effect size	Standard error	Lower limit	Upper limit	Z-value	p-Value	Exp	Nov
	RA	0.48	0.45	(0.41)	1.37	1.06	0.29	10	10
	RA	0.42	0.45	(0.47)	1.31	0.93	0.35	10	10
	RA	0.25	0.45	(0.63)	1.13	0.56	0.58	10	10
	RA	1.26	0.49	0.30	2.22	2.57	0.01	10	10
	RA	0.85	0.47	(0.07)	1.77	1.82	0.07	10	10
Vaeyens, Lenoir, Williams, Mazyn, and Philippaerts (2007)									
	DT	1.86	0.36	1.15	2.57	5.15	0.00	21	23
	RA	2.02	0.37	1.29	2.74	5.44	0.00	21	23
	EMM	1.00	0.32	0.37	1.62	3.11	0.00	21	23
	EMM	0.86	0.32	0.24	1.48	2.72	0.01	21	23
Williams, Hodges, North, and Barton (2006)									
	DT	1.34	0.54	0.29	2.40	2.50	0.01	8	9
	DT	1.28	0.53	0.23	2.32	2.39	0.02	8	9
	RA	1.14	0.52	0.11	2.16	2.17	0.03	8	9
Williams and Davids (1998)									
	DT	1.06	0.44	0.21	1.91	2.43	0.02	12	12
	MT	1.09	0.44	0.23	1.95	2.49	0.01	12	12
	DT	0.74	0.42	(0.09)	1.57	1.75	0.08	12	12
	RA	1.17	0.44	0.30	2.04	2.65	0.01	12	12
	EMM	0.85	0.43	0.01	1.69	1.99	0.05	12	12
	EMM	0.91	0.43	0.07	1.75	2.12	0.03	12	12
	DT	1.27	0.45	0.39	2.15	2.84	0.00	12	12
	VK	0.95	0.43	0.11	1.79	2.21	0.03	12	12
Zoudji, Thon, and Debu (2010)									
	RA	0.84	0.43	0.01	1.67	1.97	0.05	12	12
Random		1.40	0.07	1.26	1.55	19.11			

Note. VK – verbalized knowledge; EMM – eye movement measures; DT – decision time; RA – response accuracy; MA – movement accuracy; MT – movement time; () – negative values.

response" is a moderator for decision time, contrary to "stimulus presentation" (see Table 1). The Q-test for heterogeneity ($Q_{(within)}$) applied to the "requisite response" moderating variable revealed homogeneity for *sport performance* condition with $Q_{(within)}$ $(6) = 6.09$, $p > 0.05$. The Q-test for heterogeneity applied to "stimulus presentation" revealed homogeneity for *in situ* condition with $Q_{(within)}$ $(1) = 0.05$, $p > 0.05$. The other conditions revealed significant results for heterogeneity (see Table 3).

Table 2
Results of expertise difference for verbalized knowledge (VK) and eye movement measures (EMM).

	N	ES	95% CI		Q	df (Q)	p-Value
VK							
Total	12	1.31	[1.00	1.63]	4.13	11	0.97
Requisite response							
Verbal reports	4	1.30	[0.83	1.77]	1.28	3	0.73
Micro-movements	8	1.32	[0.90	1.75]	2.84	7	0.90
Sport performance	–	–	–	–	–	–	–
Total between					0.00	1	0.95
Stimulus presentation							
Slide	4	1.22	[0.77	1.66]	0.64	3	0.89
Video	8	1.42	[0.97	1.87]	3.09	7	0.88
In situ	–	–	–	–	–	–	–
Total between					0.39	1	0.63
EMM							
Total	25	1.21	[0.91	1.51]	46.22	24	0.00
Requisite response							
Verbal reports	–	–	–	–	–	–	–
Micro-movements	9	1.20	[0.38	2.03]	33.73	8	0.00
Sport performance	16	1.13	[0.88	1.37]	12.38	15	0.65
Total between					0.02	1	0.86
Stimulus presentation							
Slide	1	1.22	[0.42	2.03]	9.36	0	1.00
Video	17	1.20	[0.81	1.60]	40.01	16	0.00
In situ	7	1.24	[0.75	1.73]	6.01	6	0.42
Total between					0.01	2	0.99

Note. CI = confidence interval.

Table 3
Results of expertise difference for decision time (DT) and response accuracy (RA).

	N	ES	95% CI	Q	df (Q)	p-Value
DT						
Total	23	1.39	[1.10 1.67]	54.76	22	0.00
Requisite response						
Verbal reports	1	4.24	[2.66 5.83]	0.00	0	1.00
Micro-movements	15	1.32	[0.99 1.66]	34.93	14	0.00
Sport performance	7	1.29	[0.95 1.62]	6.09	6	0.41
Total between				13.00	2	0.00
Stimulus presentation						
Slide	8	1.45	[0.89 2.01]	26.1	7	0.00
Video	13	1.34	[0.98 1.69]	27.52	12	0.00
In situ	2	1.76	[0.80 2.72]	0.05	1	0.82
Total between				0.71	2	0.70
RA						
Total	43	1.61	[1.29 1.93]	179.73	42	0.00
Requisite response						
Verbal reports	3	1.74	[0.64 2.85]	8.59	2	0.01
Micro-movements	29	1.38	[0.99 1.77]	137.91	28	0.00
Sport performance	11	2.19	[1.68 2.70]	19.01	10	0.07
Total between				6.06	2	0.04
Stimulus presentation						
Slide	5	1.92	[0.99 2.85]	21.01	4	0.00
Video	30	1.35	[0.99 1.72]	128.04	29	0.00
In situ	8	2.59	[1.87 3.32]	12.94	7	0.08
Total between				9.41	2	0.00

Note. CI = confidence interval.

Response accuracy (RA)

The 43 effect sizes in which RA was identified revealed a significant effect size ES = 1.61, 95% CI [1.29, 1.93], with $Z = 9.96$, $p < 0.001$. This was the dependent variable that presented the highest number of measurements from the whole sample of studies analysed. The Q-test for heterogeneity revealed significant values $Q_{(t)}$ (42) = 179.73, $p < 0.001$, i.e., heterogeneity (see Table 2). The fail-safe *n* was 4364, signifying that approximately 4360 studies averaging null results would be needed to modify the significance of the current effect size for the RA variable.

The overall estimate of the effect size between groups was calculated for each of the moderating variables with significant results for "requisite responses" $Q_{(\text{bet})}$ (2) = 6.066, $p < 0.05$ and "stimulus presentation" $Q_{(\text{bet})}$ (2) = 8.92, $p < 0.05$. This finding indicates that the proposed moderating variables were really moderating for response accuracy (see Table 2). Moreover, the Q-test for heterogeneity ($Q_{(\text{within})}$) revealed homogeneity just for *sport performance* condition in the moderating variable "requisite response" $Q_{(\text{within})}$ (10) = 19.01, $p > 0.05$ and for *in situ* condition in the moderating variable "stimulus presentation" $Q_{(\text{within})}$ (7) = 12.94, $p > 0.05$. The other conditions revealed heterogeneity in the results (see Table 3).

Movement accuracy (MA)

The 5 effect sizes in which MA was identified revealed a significant effect size ES = 3.47, 95% CI [2.23, 4.71], with $Z = 5.48$, $p < 0.001$. The Q-test for heterogeneity revealed non-significant values $Q_{(t)}$ (4) = 9.01, $p > 0.05$, i.e., homogeneity. The fail-safe *n* was 87, signifying that approximately 100 studies averaging null results would be needed to modify the significance of the current effect size for the MA variable. All of the studies used *sport performance* in *in situ* conditions. Thus, subsequent analyses of effect of moderating variables were not conducted.

Movement time (MT)

The 3 effect sizes in which MT was identified revealed a highly significant effect size ES = 1.37, 95% CI [0.82, 1.91], with $Z = 4.89$, $p < 0.001$. The Q-test for heterogeneity revealed non-significant values $Q_{(t)}$ (2) = 0.70, $p > 0.05$, i.e., homogeneity. The fail-safe *n* was 16, signifying that approximately 20 studies averaging null results would be needed to modify the significance of the current effect size for MT variable. All of the studies used *sport performance* in *in situ* conditions. Thus, subsequent analyses of effect of moderating variables were not undertaken.

Discussion

This study provided a quantitative review of the literature to identify the influence of key prevalent research protocol conditions on the most common variables used to measure decision-making in studies of sport performance. We examined the influence of "requisite responses" and "stimulus presentation" methods on some of the dependent variables selected to distinguish expertise in decision-making behaviours in sport. In general, the results indicated that the study of decision-making in sport needs to consider how participants detect information by acting in a performance environment. Sport is a behavioural context that can clearly reveal how information can be detected via activity to regulate performance behaviours (Araújo et al., 2006; Pinder et al., 2011).

Analysis of the moderator variable "requisite responses" revealed that 'verbalized knowledge' and 'eye movement measures' were independent of the type of the behaviour required of participants. In contrast, both 'decision time' and 'response accuracy' revealed that "requisite responses" influenced the magnitude of the difference between novices and experts in decision-making tasks. Differences in the effect of the moderator variable "requisite responses" on 'decision time' and 'response accuracy' compared to 'verbalized knowledge' and 'eye movement measures' can be explained by the fact that when performance outcomes were measured, the expertise effect is highlighted (Ericsson & Ward, 2007). It is worth noting that the *sport performance* condition for 'eye movement measures', 'decision time' and 'response accuracy' was the unique experimental condition that displayed homogeneity in the effect of expertise ($p > 0.05$), i.e., consistency under their effects. This finding implies that the effect of expertise was more consistent for 'eye movement measures', 'decision time' and 'response accuracy' when individuals were actually required to perform sport actions in experimental studies.

These findings supported the idea that the time to perform an action and the accuracy of decisions are more consistent when performers are required to *perceive to act* than when they *perceive to communicate* (Dicks et al., 2010; Van der Kamp et al., 2008). For instance, expertise differences are highlighted when experts and novices were required to perform a sport action in comparison to when they were required to report a decision or judge a situation pressing a button. Thus, designing task constraints which decouple processes of perception and action (e.g., using verbal reports or micro-movements to express decision-making) may inadvertently emphasize the use of perception for object identification or for judging (i.e., allocentric information), rather than perception on action possibilities such as to catch or to intercept a ball (i.e., egocentric information). This type of design feature has consequences for studying decision-making behaviours of performers in dynamic action contexts like sport.

Tasks requiring a performance movement response are distinct from those requiring verbal communication or a micro-movement for judgement, since the information that guides coordination and control of actions is different from the information used to describe an occurrence in a performance environment (Michaels, 2000). This issue has been raised by ecological psychologists in general emphasizing the need to understand human behaviours based on the interactions between individuals and their performance environment (Araújo et al., 2006; Davids & Araújo, 2010; Pinder et al., 2011; Warren, 2006).

Results on the moderator variable "stimulus presentation" revealed that 'verbalized knowledge', 'eye movement measures' and 'decision time' were independent of the type of the stimulus used in research protocols. In contrast, 'response accuracy' revealed that the type of "stimulus presentation" influenced the magnitude of the reported difference between novices and experts in decision-making tasks.

Findings on 'eye movement measures', 'response accuracy' and 'decision time' (despite the absence of moderating effects of "stimulus presentation" for 'eye movement measures' and 'decision time') showed that the *in situ* condition was the unique experimental condition that displayed homogeneity in the effect of expertise ($p > 0.05$), i.e., consistency under their effects. This finding suggests that, in contrast to other measures (i.e., slide and video), the magnitude of the variation between experts and novices was maintained across studies which included *in situ* condition. As reported by Mann et al. (2007) on the study of perceptual-cognitive skills the use of a specific performance environment itself or sampling environment conditions in experimental tasks helps capture the same information–movement relationship as observed during performance (Davids, Kingsbury, Bennett, & Handford, 2001; Ericsson & Ward, 2007). These results have implications on future research and reinforced the challenge to study decision-making expertise using representative experimental tasks (Araújo, Davids, & Passos, 2007; Ericsson & Ward, 2007; Pinder et al., 2011).

In analyses of movement accuracy and movement time, all studies in the sample measured participants' *sport actions* in *in situ* conditions. Thus, in opposition to the outcomes for other dependent variables, effects of moderating variables were not analysed. Results for movement accuracy and movement time displayed consistency, i.e., homogeneity. In addition, analysis of movement accuracy also revealed the highest overall effect size in comparison with the other dependent variables. Despite the relatively small number of studies, the data highlighted some important trends in the study of expertise effects in decision-making in sport. Goal directed behaviours measured with movement accuracy and movement time required participants to make perceptual judgements in specific performance environments that allowed the emergence of unrestricted functional responses. In this type of tasks, individuals assumed a more active role in the environment instead of acting independently of the external objects or events (Van der Kamp et al., 2008).

Results on movement accuracy and movement time revealed a small fail-safe n (approximately 100 and 20, respectively) which means that a low number of studies were sufficient to average null results. This is a limitation of our analysis. However, the low number of studies using movement accuracy and movement time measures is a consequence of a recent emphasis on these variables to assess decision-making behaviour and not a bias of publication promoted by our literature search methodology. Although many studies with the purpose of explaining perceptual-cognitive expertise were identified, the topic of decision-making in sport has been explored in only a few studies in recent years.

Conclusion

We observed that verbalized knowledge and eye movement measures did not present any effect of moderating variables. In contrast, decision time and response accuracy measures revealed some effects of moderating variables. Based on homogeneity of the results the effect of expertise was best captured when players were required to *sport performance* in *in situ* conditions. Due to small number of studies it was not possible to test the influence of the moderating variables on movement accuracy and movement time measures.

This meta-analysis only selected electronic publications emerging in the literature since 1995. There were also a lot of non-electronic publications, dissertations or conference proceedings in this area of research not considered, in order to maintain coherent selection criteria concerning our database and the quality of research considered (e.g., all been subjected to external peer review for publication). Despite these limitations some interesting trends in the published data were highlighted on the effect of the requisite response on decision-making expertise.

Further analyses, with an increased number of studies evaluated, are needed in order to test the consistency of the reported results. Future research is also needed to develop more studies on the effects of expertise on decision-making in sport considering requisite responses of participants in simulating performance environment conditions (i.e., the same actions observed during actual competitive performance). Use of *in situ* task constraints with performers required to perform sport actions appeared the most functional empirical protocols to enhance validity of data.

Acknowledgements

This research was supported by a financial grant from the Portuguese Foundation for Science and Technology (SFRH/BD/36225/2007) awarded by the first author.

References[1]

*Abernethy, B., Baker, J., & Cotê, J. (2005). Transfer of pattern recall skills may contribute to the development of sport expertise. *Applied Cognitive Psychology, 19*(6), 705–718. http://dx.doi.org/10.1002/acp.1102.

*Abernethy, B., & Neal, R. J. (1999). Visual characteristics of clay target shooters. *Journal of Science and Medicine in Sport, 2*(1), 1–19. http://dx.doi.org/10.1016/S1440-2440(99)80180-7.

Araújo, D., Davids, K., & Hristovski, R. (2006). The ecological dynamics of decision making in sport. *Psychology of Sport and Exercise, 7*(6), 653–676. http://dx.doi.org/10.1016/j.psychsport.2006.07.002.

Araújo, D., Davids, K., & Passos, P. (2007). Ecological validity, representative design, and correspondence between experimental task constraints and behavioral setting: comment on Rogers, Kadar, and Costall (2005). *Ecological Psychology, 19*(1), 69–78. http://dx.doi.org/10.1080/10407410709336951.

Bar-Eli, M., Plessner, H., & Raab, M. (2011). *Judgement, decision making and success in sport*. West Sussex: Wiley-Blackwell.

Bar-Eli, M., & Raab, M. (2009). Judgment and decision making in sport and exercise: a concise history and present and future perspectives. In D. Araújo, H. Ripoll, & M. Raab (Eds.), *Perspectives on cognition and action in sport* (pp. 149–156). New York: Nova Science Publishers.

Beer, R. D. (2003). The dynamics of active categorical perception in an evolved model agent. *Adaptive Behavior, 11*(4), 209–243.

*Bertrand, C., & Thullier, F. (2009). Effects of player position task complexity in visual exploration behavior in soccer. *International Journal of Sport Psychology, 40*(2), 306–323.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2009). *Introduction to meta-analysis*. West Sussex: Wiley.

Cañal-Bruland, R., & Van der Kamp, J. (2009). Action goals influence action-specific perception. *Psychonomic Bulletin & Review, 16*(6), 1100–1105. http://dx.doi.org/10.3758/PBR.16.6.1100.

Cordovil, R., Araujo, D., Davids, K., & Gouveia, L. (2009). The influence of instructions and body-scaling as constraints on decision-making processes in team sports. *European Journal of Sport Science, 9*(3), 169–179. http://dx.doi.org/10.1080/17461390902763417.

Davids, K., & Araújo, D. (2010). The concept of 'organismic asymmetry' in sport science. *Journal of Science and Medicine in Sport, 13*(6), 633–640. http://dx.doi.org/10.1016/j.jsams.2010.05.002.

Davids, K., Kingsbury, D., Bennett, S., & Handford, C. (2001). Information–movement coupling: implications for the organization of research and practice during acquisition of self-paced extrinsic timing skills. *Journal of Sports Sciences, 19*(2), 117–127. http://dx.doi.org/10.1080/026404101300036316.

*Del Villar, F., Gonzalez, L. G., Iglesias, D., Moreno, M., & Cervello, E. M. (2007). Expert–novice differences in cognitive and execution skills during tennis competition. *Perceptual and Motor Skills, 104*(2), 355–365. http://dx.doi.org/10.2466/pms.104.2.355-365.

Dicks, M., Button, C., & Davids, K. (2010). Examination of gaze behaviors under in situ and video simulation task constraints reveals differences in information pickup for perception and action. *Attention, Perception, & Psychophysics, 72*(3), 706–720. http://dx.doi.org/10.3758/APP.72.3.706.

Ericsson, K. A., & Ward, P. (2007). Capturing the naturally occurring superior performance of experts in the laboratory. *Current Directions in Psychological Science, 16*(6), 346. http://dx.doi.org/10.1111/j.1467-8721.2007.00533.x.

*Fontana, F. E., Mazzardo, O., Mokgothu, C., Furtado, O., Jr., & Gallagher, J. D. (2009). Influence of exercise intensity on the decision-making performance of experienced and inexperienced soccer players. *Journal of Sport & Exercise Psychology, 31*(2), 135–151.

*González, L., Arroyo, M., Domínguez, A., Gallego, D., & Alvarez, F. (2009). Relation between knowledge and decision making in tennis players and its influence in sport expertise. *RICYDE: Revista Internacional de Ciencias del Deporte, 5*(17), 60–75.

*Gygax, P., Wagner-Egger, P., Parris, B., Seiler, R., & Hauert, C. (2008). A psycholinguistic investigation of football players' mental representations of game situations: does expertise count? *Swiss Journal of Psychology, 67*(2), 85–95. http://dx.doi.org/10.1024/1421-0185.67.2.85.

Hagger, M. S. (2006). Meta-analysis in sport and exercise research: review, recent developments, and recommendations. *European Journal of Sport Science, 6*(2), 103–115. http://dx.doi.org/10.1080/17461390500528527.

Hastie, R. (2001). Problems for judgment and decision making. *Annual Review of Psychology, 52*(1), 653–683. http://dx.doi.org/10.1146/annurev.psych.52.1.653.

Hedges, L. V., & Olkin, I. (1985). *Statistical methods for meta-analysis*. New York: Academic Press.

*Helsen, W. F., & Starkes, J. L. (1999). A multidimensional approach to skilled perception and performance in sport. *Applied Cognitive Psychology, 13*(1), 1–27.

Hodges, N. J., Huys, R., & Starkes, J. L. (2007). Methodological review and evaluation of research in expert performance in sport. In G. Tenenbaum, & R. Eklund (Eds.), *Handbook of sport psychology* (3rd ed.). (pp. 161–183) New Jersey: John Wiley & Sons.

*Huber, J. (1997). Differences in problem representation and procedural knowledge between elite and nonelite springboard divers. *The Sport Psychologist, 11*(2), 142–159.

[1] *References included in the meta-analysis.

*Jackson, R., & Mogan, P. (2007). Advance visual information, awareness, and anticipation skill. *Journal of Motor Behavior, 39*(5), 341–351. http://dx.doi.org/10.3200/JMBR.39.5.341-352.

*Jackson, R. C., Warren, S., & Abernethy, B. (2006). Anticipation skill and susceptibility to deceptive movement. *Acta Psychologica, 123*(3), 355–371. http://dx.doi.org/10.1016/j.actpsy.2006.02.002.

*Kioumourtzoglou, E., Kourtessis, T., Michalopoulou, M., & Derri, V. (1997). Expertise in water-polo. *Journal of Human Movement Studies, 33*(5), 205–228.

*Kioumourtzoglou, E., Kourtessis, T., Michalopoulou, M., & Derri, V. (1998). Differences in several perceptual abilities between experts and novices in basketball, volleyball and water-polo. *Perceptual and Motor Skills, 86*(3), 899–912.

*Lee, S., Kim, S., & Seung-Ha, P. (2009). Self-paced sport events under temporal constraints: visual search, quiet eye, expertise and constrained performance time in far aiming tasks. *International Journal of Applied Sports Sciences, 21*(2), 146–161.

Mann, D. T., Williams, A. M., Ward, P., & Janelle, C. M. (2007). Perceptual-cognitive expertise in sport: a meta-analysis. *Journal of Sport & Exercise Psychology, 29*(4), 457.

*Martell, S., & Vickers, J. (2004). Gaze characteristics of elite and near-elite athletes in ice hockey defensive tactics. *Human Movement Science, 22*(6), 689–712. http://dx.doi.org/10.1016/j.humov.2004.02.004.

*McMorris, T., & Graydon, J. (1996). The effect of exercise on the decision-making performance of experienced and inexperienced soccer players. *Research Quarterly for Exercise and Sport, 67*(1), 109–114.

Michaels, C. F. (2000). Information, perception, and action: what should ecological psychologists learn from Milner and Goodale (1995)? *Ecological Psychology, 12*(3), 241–258. http://dx.doi.org/10.1207/S15326969ECO1203_4.

*Nakamoto, H., & Mori, S. (2008). Effects of stimulus–response compatibility in mediating expert performance in baseball players. *Brain Research, 1189*, 179–188. http://dx.doi.org/10.1016/j.brainres.2007.10.096.

*Nielsen, T. M., & Sue, L. M. (2001). Response selection and execution skills of professionals and novices during singles tennis competition. *Perceptual and Motor Skills, 93*(2), 541–555. http://dx.doi.org/10.2466/PMS.93.5.541-555.

*Paull, G., & Glencross, D. (1997). Expert perception and decision making in baseball. *International Journal of Sport Psychology, 28*(1), 35–56.

*Petit, J. P., & Ripoll, H. (2008). Scene perception and decision making in sport simulation: a masked priming investigation. *International Journal of Sport Psychology, 39*(1), 1–19.

Pinder, R., Davids, K., Renshaw, I., & Araújo, D. (2011). Representative learning design and functionality of research and practice in sport. *Journal of Sport & Exercise Psychology, 33*(1), 146–155.

*Reina, R., Moreno, F. J., & Sanz, D. (2007). Visual behavior and motor responses of novice and experienced wheelchair tennis players relative to the service return. *Adapted Physical Activity Quarterly, 24*(3), 254.

*Ripoll, H., Kerlirzin, Y., Stein, J. F., & Reine, B. (1995). Analysis of information processing, decision making, and visual strategies in complex problem solving sport situations. *Human Movement Science, 14*(3), 325–349.

Rosenthal, R. (1991). *Meta-analytic procedures for social research*. Newbury Park: CA: Sage.

*Rowe, R., Horswill, M., Kronvall-Parkinson, M., Poulter, D., & McKenna, F. (2009). The effect of disguise on novice and expert tennis players' anticipation ability. *Journal of Applied Sport Psychology, 21*(2), 178–185. http://dx.doi.org/10.1080/10413200902785811.

*Savelsbergh, G., Williams, A. M., Van Der Kamp, J., & Ward, P. (2002). Visual search, anticipation and expertise in soccer goalkeepers. *Journal of Sports Sciences, 20*(3), 279–287.

*Shim, J., Carlton, L., Chow, J., & Chae, W. (2005). The use of anticipatory visual cues by highly skilled tennis players. *Journal of Motor Behavior, 37*(2), 164–175. http://dx.doi.org/10.3200/JMBR.37.2.164-175.

Simmons, J., Nelson, L., & Simonsohn, U. (2011). False-positive psychology: undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science, 22*(11), 1359–1366. http://dx.doi.org/10.1177/0956797611417632.

*Ste-Marie, D. (1999). Expert–novice differences in gymnastic judging: an information-processing perspective. *Applied Cognitive Psychology, 13*(3), 269–281. http://dx.doi.org/10.1002/(SICI)1099-0720(199906)13:3<269::AID-ACP567>3.0.CO;2-Y.

*Tenenbaum, G., Sar-El, T., & Bar-Eli, M. (2000). Anticipation of ball location in low and high-skill performers: a developmental perspective. *Psychology of Sport and Exercise, 1*(2), 117–128. http://dx.doi.org/10.1016/S1469-0292(00)00008-X.

*Vaeyens, R., Lenoir, M., Williams, A. M., Mazyn, L., & Philippaerts, R. M. (2007). The effects of task constraints on visual search behavior and decision-making skill in youth soccer players. *Journal of Sport & Exercise Psychology, 29*(2), 147.

Van der Kamp, J., Rivas, F., Van Doorn, H., & Savelsbergh, G. (2008). Ventral and dorsal system contributions to visual anticipation in fast ball sports. *International Journal of Sport Psychology, 39*(2), 100–130.

Warren, W. H. (2006). The dynamics of perception and action. *Psychological Review, 113*(2), 358–389. http://dx.doi.org/10.1037/0033-295X.113.2.358.

*Williams, A. M., & Davids, K. (1998). Visual search strategy, selective attention, and expertise in soccer. *Research Quarterly for Exercise and Sport, 69*(2), 111–128.

Williams, A. M., & Ericsson, K. A. (2005). Perceptual-cognitive expertise in sport: some considerations when applying the expert performance approach. *Human Movement Science, 24*(3), 283–307. http://dx.doi.org/10.1016/j.humov.2005.06.002.

*Williams, A. M., Hodges, N. J., North, J. S., & Barton, G. (2006). Perceiving patterns of play in dynamic sport tasks: investigating the essential information underlying skilled performance. *Perception, 35*(3), 317–332. http://dx.doi.org/10.1068/p5310.

Williams, A. M., & Ward, P. (2007). Anticipation and decision making: exploring new horizons. *Handbook of Sport Psychology, 3*, 203–223.

*Zoudji, B., Thon, B., & Debu, B. (2010). Efficiency of the mnemonic system of expert soccer players under overload of the working memory in a simulated decision-making task. *Psychology of Sport and Exercise, 11*(1), 18–26. http://dx.doi.org/10.1016/j.psychsport.2009.05.006.