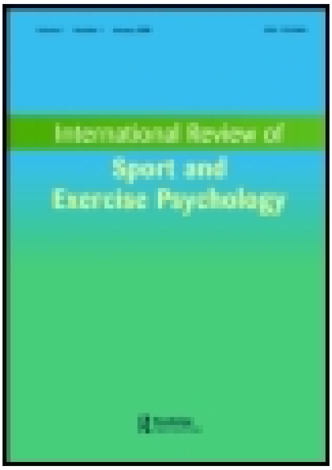

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The two modes of an athlete: dual-process theories in the field of sport

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The two modes of an athlete: dual-process theories in the field of sport

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The goal of the present article is to introduce dual-process theories – in particular the default-interventionist model – as an overarching framework for attention-related research in sports. Dual-process theories propose that two different types of processing guide human behavior. Type 1 processing is independent of available working memory capacity (WMC), whereas Type 2 processing depends on available working memory capacity. We review the latest theoretical developments on dual-process theories and present evidence for the validity of dual-process theories from various domains. We demonstrate how existing sport psychology findings can be integrated within the dual-process framework. We illustrate how future sport psychology research might benefit from adopting the dual-process framework as a meta-theoretical framework by arguing that the complex interplay between Type 1 and Type 2 processing has to be taken into account in order to gain a more complete understanding of the dynamic nature of attentional processing during sport performance at varying levels of expertise. Finally, we demonstrate that sport psychology applications might benefit from the dual-process perspective as well: dual-process theories are able to predict which behaviors can be more successfully executed when relying on Type 1 processing and which behaviors benefit from Type 2 processing.

Keywords: dual-process; working memory; attention; sport

Along with the multifaceted challenges the Olympic athletes were confronted with in their respective sports during London's 2012 Olympic Games, England's capital posed an additional 'challenge' not only to the athletes but also to the millions of visiting spectators from all over the world. At first sight the 'challenge' we are referring to has nothing to do with sports but is suitable for introducing the overarching theme of this article. The 'challenge' we are referring to is caused by the fact that people in Great Britain drive on the left side of the road instead of the right side as in most other nations. This not only makes driving in London for people from right-hand traffic countries a real challenge compared to the effortless habit of driving in their home country, but the simple everyday routine of crossing the road also suddenly becomes a problem that requires careful attention.

People who have grown up in right-hand traffic countries have become accustomed to first orient their gaze and attention to the left before they cross the road, as this is where

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approaching cars are expected to come from. In the course of time this looking behavior becomes automated (or proceduralized) and therefore requires less and less controlled attention. In this manner people become well 'equipped' for crossing the road in right-hand traffic countries as they adapt to the constraints imposed upon them in their home environments. Unfortunately, these people were less well 'equipped' to cross the road when visiting London for the 2012 Olympics and therefore special instructions were installed at road crossings telling people to first look to the right to override their automatic tendency of orienting their attention to the left.

This article is not about crossing the road and this anecdotal example does not have anything to do with Olympic sports or sports in general, but it is suitable to introduce two different types of information processing: one requiring controlled attention and one not requiring controlled attention.

Although researchers have acknowledged the importance of attention in sport (Abernethy, 2001; Furley & Memmert, 2010; Memmert, 2009; Moran, 1996; Wulf, 2007), research in this area is underdeveloped and has been conducted in a piecemeal fashion without a suitable overarching theoretical framework: 'a suitable framework to study the influence of attention on sport skills has not been established' (Boucher, 2008, p. 326). In addition, attentional accounts of skill acquisition and performance in sports – e.g. Beilock and Carr's (2001) concept of 'expertise-induced amnesia' and Masters' (1992) emphasis on the benefits of acquiring skills implicitly – may have led to the belief that controlled attention is necessarily detrimental in the sport performance context as it is likely to disrupt learning and skill execution. At an extreme, Dreyfus (2002) proposed that an expert performer's body will take over and there will be 'no interplay of automatic and controlled factors when all is going well in an expert's attuned embodied activity, no dynamic interaction of cognition and reaction or of strategy and skill' (Sutton, Mcilwain, Christensen, & Geeves, 2011, p. 89). However, this one-sided notion of attention in skilled sport performance has been challenged by recent evidence (e.g. Nyberg, 2014) and theorizing (Sutton et al., 2011; Toner & Moran, 2014), suggesting that skilled sport performers are required to alternate between different modes of processing in order to meet the complex demands presented by competitive environments.

Based on the aforementioned shortcomings in the sport attention literature, we argue that recent developments in dual-process theories (Evans & Stanovich, 2013a, 2013b) in cognitive psychology seem to be a promising framework for furthering understanding on the dynamic influence of attention in sport performance.

Dual-process theories

The distinction of two different types of information processing has a long tradition in both psychology and philosophy and reaches back to ancient times (Frankish & Evans, 2009). On a very general level, numerous theories agree that human behavior is controlled by two qualitatively different modes of processing, automatic and controlled processing, for example dual-process theories of social cognition (Smith & DeCoster, 2000; Strack & Deutsch, 2004), person perception (e.g. Gilbert, 1989; Zárate, Sanders, & Garza, 2000), judgment and reasoning (De Neys, 2006; Glöckner & Witteman, 2010), attention (Barrett, Tugade, & Engle, 2004; Schneider & Shiffrin, 1977), mental control (e.g. Wenzlaff & Wegner, 2000), self-regulation (Baumeister & Heatherton, 1996), and emotion (Teasdale, 1999). These theories share the idea that the two forms of cognitive processing are characterized specifically by their reliance on attentional control, which can be defined as the goal-directed allocation of cognitive processing resources to internal and external stimuli (Pashler, Johnston, & Ruthruff, 2001; Posner & Petersen, 1990). However, the exact conceptualizations of automatic and controlled processing have been subject to debate, just like their relationship to each other (e.g. Keren & Schul, 2009; Gigerenzer, 2011).

Recently attempts have been made to establish the commonalities of the various domain-specific dual-process theories (e.g. Kahneman, 2011; Stanovich, 1999). In this respect, both Stanovich (1999) and Kahneman (2011) argue that human behavior in general is controlled by two different systems, which they named *System 1* and *System 2*. System 1 is believed to operate quickly with hardly any effort as it does not depend upon controlled attention, whereas System 2 is responsible for mental activities that require controlled processing. According to Kahneman (2011, p. 24), both systems are active whenever we are awake: '*System 1* runs automatically and *System 2* is normally in a comfortable low-effort mode, in which only a fraction of its capacity is engaged'.

However, the dual-system distinction has recently been criticized for lacking conceptual clarity (Keren & Schul, 2009; see also Gigerenzer, 2011; Kruglanski & Gigerenzer, 2011). Although the two-system terminology has become popular, it can be considered problematic as it might be used as a synonym for a two-minds hypothesis and usually the two proposed systems convey little more than two types of information processing. In an attempt to address this issue, Evans and Stanovich (2013a) proposed two distinct types of processing within their default-interventionist framework instead of two separate systems. *Type 1* processes are both initiated and completed in the presence of relevant triggering conditions. They do not require working memory. In contrast, *Type 2* processes require working memory for hypothetical thinking and mental simulation (Evans & Stanovich, 2013a). Hence, Type 1 processes are labeled autonomous – defined as initiated and completed in the presence of relevant triggering conditions – whereas Type 2 processes are labeled controlled – defined as requiring working memory.

Although the default-interventionist framework has received some criticism for actually being a single process model (Kruglanski, 2013) or for not classifying as a conventional psychological theory (Keren, 2013), we will argue that it seems a useful meta-theoretical framework for understanding behavior in everyday contexts such as sport, for reconciling existing findings, and for deriving testable hypotheses. Before we continue to highlight the utility of the framework (Evans & Stanovich, 2013a, 2013b) for sports, it is necessary to describe the key concepts and assumptions of the framework.

The default-interventionist framework

Thompson (2013) clarifies important aspects of the dual-process debate by reconciling Evans and Stanovich's (2013a, 2013b) proposal with some of the criticism (Keren, 2013; Kruglanski, 2013). Most importantly, Thompson (2013) clarifies that Type 1 processes should be characterized as those whose execution is mandatory in the presence of their triggering conditions. According to Thompson (2013), a Type 1 process can clearly be conceptualized as autonomous if it is triggered by the current context and runs to completion without the controlled intention of the person and with no reliance on working memory. Hence, Type 1 processes can be distinguished from Type 2 processes by the assumption that the response/solution to a problem has become part of its cognitive representation: for example when solving the equation 2*4. In this case the solution 8 is triggered by the context without requiring further controlled processing as it is part of the cognitive representation of that problem (at least for most adults in industrialized nations). The solution has become part of the cognitive representation because of learning experiences. Thompson (2013) argues that this conceptualization is not incompatible with evidence showing that autonomous processes can be affected by top-down control (Keren, 2013; Keren & Schul, 2009), and also not with the observation of the frequently occurring transitions from controlled to autonomous processes (Schneider & Shiffrin, 1977) as the distinctive feature of Type 1 processing is that it does not require working memory to arrive at a response.

Type 2 processes are needed either to override the triggered response that is part of a representation/problem space or for a response that has never become part of a representation/problem space, as for example when solving the equation 1578*47. While Thompson (2013) states that Type 2 processes can also be triggered by the context, only Type 1 processes autonomously run to completion as the response is a mandatory part of the cognitive representation, whereas Type 2 processes can only be initiated autonomously and subsequently require working memory engagement to be completed. As working memory engagement is not an all or nothing criterion, but instead can vary according to the demands of the task, Type 2 processes should be defined along a continuum regarding their demands on working memory (Thompson, 2013).

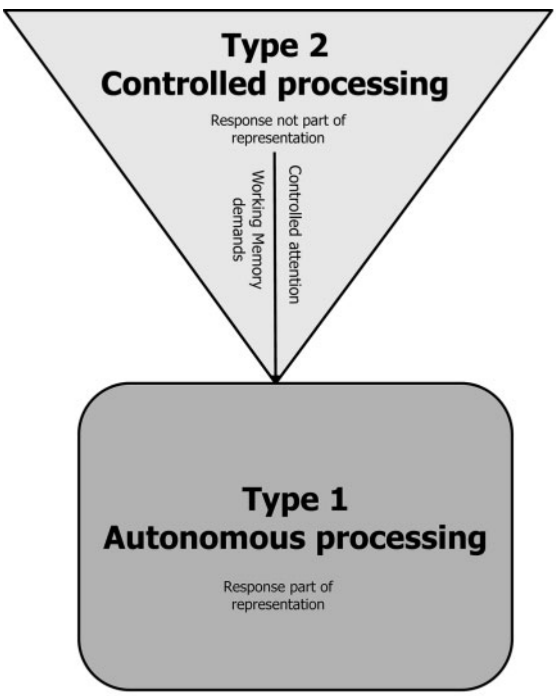
In sum, Type 1 processing may be beneficial because it allows for the fast and effortless execution of behavioral responses and the integration of large amounts of information. The downside of Type 1 processing is that it is only an option as soon as elements of a problem have been integrated into a cognitive representation, a process that is assumed to rely on rather long periods of mostly associative learning (Strack & Deutsch, 2004; Thompson, 2013). Therefore, Type 1 processing is not suited for dealing with novel problems. Type 2 processing, on the other hand, is well equipped for dealing with novel problems, although it takes time and effort which may not be available in a given situation. Nevertheless, without Type 2 processing, humans would not be able to deal with situations or problems they are not used to, or with situations in which their triggered reactions are inappropriate.

An understanding of dual-process models that can be considered problematic is that different features are sometimes associated with Type 1 and Type 2 processing. For example, efficient processing is sometimes also assumed to be unconscious or implicit (see Bargh, 1994, for an early discussion). However, this need not be the case. For example, researchers should not assume that just because a process is shown to be efficient, this process is necessarily also unconscious (e.g. Moors & DeHouwer, 2007). Type 1 processing does not depend on working memory capacity (WMC) whereas Type 2 processing does depend on working memory capacity. When researchers assume further process characteristics, particularly when referring to processes as implicit or unconscious, they should not infer these characteristics solely from the process being efficient. Instead, they need to provide evidence for the additionally assumed process characteristics (e.g. implicit or unconscious).

Different dual-process models (that may otherwise make similar predictions) have different assumptions about how both kinds of processing interact (Glöckner & Witteman, 2010). Broadly, dual-process models can be categorized into three groups: pre-emptive models, parallel-competitive models, and default-interventionist models. Pre-emptive models assume that when people face a certain task, one kind of processing must be selected before processing itself starts. Parallel-competitive models assume that both kinds of processing compete during the entire task. Default-interventionist models assume that Type 1 processing is the default mode, which is always activated when confronted with a given situation (such as walking through London, or dribbling a ball on the soccer field) or encountering a particular problem (such as being asked to solve an equation, or returning a tennis serve). Type 2 processing is only additionally activated when Type 1 processing does not reach a solution or when additional contextual information casts doubt on the initially triggered solution (such as a warning sign when crossing traffic, or when an opponent basketball defender anticipates the intended action). In some situations all three categories of models will make the same predictions. However, for some questions the distinction can be crucial: whenever researchers are interested in the interplay of Type 1 and Type 2 processing, they need to decide on one group of dual-process models. Current research seems to favor the default-interventionist framework (Evans & Stanovich, 2013a, 2013b; Glöckner & Witteman, 2010).

It is important to note that dual-process models in general and also the default-interventionist framework can easily be misunderstood as suggesting a binary all-or-nothing approach, where behavior is either guided by automatic or by controlled processing. However, most dual-process models and particularly the default-interventionist approach assume that the majority of real-world behaviors will not depend on one type of processing alone, but on a mixture of both (Kahneman, 2011; Strack & Deutsch, 2004). What varies between different behaviors is the extent to which Type 2 processing is involved.

Hence, people's thoughts and behaviors can rely on autonomous or on controlled processes, or somewhere in between. As illustrated in Figure 1 (cf. Fiske & Taylor, 2013),



Sub-Mode	Definition
Full control	Intentional behavior with conscious awareness
Conscious will	Experienced when a conscious thought precedes and explains a subsequent behavior
Intent	Requires having options to chose from, especially obvious when deciding against a habitual choice, and paying attention to the intended response (this would be the intervention in the within the default-interventionist model)
Individual differences in chronic accessibility	Depends on personal experience (e.g. practice – a process called proceduralization), habitual processing by particular categories or concepts, as if chronically primed,
Goal-dependent automaticity	Intentional control initiates process, but without subsequent awareness, need to monitor completion, or intending all special outcomes
Conscious priming, or postconscious	Conscious perception of prime, but no awareness of its effects on responses, depends on context
Subliminal priming, or preconscious	Prime registers on senses, but no awareness of it or its effects on responses; depends on context
Full Automaticity	Unintentional, uncontrollable, autonomous responses outside of awareness

Adapted from Fiske and Taylor (2013, p. 32)

Figure 1. The two modes of information processing. The assumed sub processes and definitions are presented on the left.

both autonomous and controlled processing can influence thought and behavior to varying degrees, depending on the context and individual differences. Although these two modes of processing can be considered as qualitatively distinct from each other, their influence on behavior can vary in degree and need not be an all-or-nothing distinction. In this respect, we are aware of the fact that the nomenclature of dual-process theories is somewhat misleading and can probably be attributed to the human tendency of simplifying complex problems through binary categorization (Wilson, 2004). Nevertheless, for the purpose of the present review we will adopt the qualitatively distinct conceptualizations of Type 1 and Type 2 processes and will propose how dual-process theories and especially the default-interventionist framework can be a useful meta-theoretical framework for understanding sport performance, reconciling independent bodies of research, and deriving new testable hypotheses in the field of sport. In this endeavor, we first clarify the key concepts of working memory and attention and especially how these cognitive concepts are assumed to be related to one another

Working memory, attention, and their interaction

Working memory can be defined as the cognitive mechanisms capable of retaining a small amount of information in an active state for use in ongoing tasks (for reviews, see Baddeley, 2007; Conway, Jarrold, Kane, Miyake, & Towse, 2007; Cowan, 1995; Miyake & Shah, 1999). The most important advance of the working memory model was the proposal of a system responsible not only for the storage of information but also for mechanisms of cognitive control and attention – named the central executive (Baddeley, 2003; Baddeley & Hitch, 1974). Baddeley (2003) claims that the central executive is the most important but least understood component of working memory. The first attempt to advance the concept came with the proposal by Baddeley (1986) to adopt Norman and Shallice's (1986) model of attentional control as the central executive. This model overlaps to a considerable extent with the aforementioned default-interventionist framework and closes the gap between working memory and the framework as both share the central tenet that behavior is controlled at two levels. The first is autonomous and based on habits and schemas (comparable to Type 1 processes), whereby cues in the environment trigger the appropriate behavior – e.g. driving on one's daily route to work. The other level is a mechanism for overriding such habits and was termed the Supervisory Attentional System (SAS, comparable to Type 2 processing). The SAS is utilized when habit patterns are no longer adequate and attention has to be deployed in a goal-directed manner – e.g. if there are roadworks on one's daily route to work and one is forced to take appropriate action to circumvent the obstruction (Shallice, 1988; Shallice & Burgess, 1991).

Attention can be defined as an umbrella term subsuming all the cognitive processes responsible for increasing or decreasing the level of activation of internal or external representations (Desimone & Duncan, 1995; Knudsen, 2007; Pashler et al., 2001; Posner & Petersen, 1990). According to Pashler et al. (2001), attention increases or decreases the level of activation according to the goals and needs people have and the stimuli that impinge on them. This attentional activation can autonomously initiate further actions, feelings or thoughts and is considered to be ubiquitous and the normal or default mode of processing (see Barrett et al., 2004, for an overview), i.e. Type 1 processing. On the other hand, Type 2 processing requires intentionally moving attention away from 'attentiongrabbing' stimuli (Logan & Gordon, 2001; Schmeichel & Baumeister, 2010). In this respect, the individual can be considered the second controller of attention besides the environment. An influential model by Norman and Shallice (1986) that accounts for both forms of attention – autonomous and controlled – is called *contention scheduling*. Contention scheduling suggests that when the autonomously activated habitual thought or behavior (Type 1 process) is inappropriate in a given situation, working memory is needed to modulate contention scheduling (Type 2 process) in order to activate additional representations or inhibit activated ones, just as assumed in the default-interventionist framework (Evans & Stanovich, 2013a).

Evidence for the default-interventionist framework

According to Evans and Stanovich (2013a, 2013b), several streams of research provide evidence for the default-interventionist framework. We will now not review these in detail, but will briefly describe them as they show considerable overlap with research conducted in the sports domain.

The first line of research that is assumed to distinguish Type 1 from Type 2 processing can be summarized as experimental manipulations which are specifically tailored to affect one type of processing while leaving the other one intact. For example, the experimenter can suppress Type 2 processes by using dual-tasks that load working memory, or speeded tasks that do not allow for sufficient time for controlled processing. In this manner, the instructions or task demands can be specifically manipulated to either encourage or suppress Type 2 processing and subsequently it is possible to evaluate whether performance can be enhanced or harmed by either type of processing. Several independent lines of research have utilized this approach in the field of sport (e.g. Beilock, Bertenthal, McCoy, & Carr, 2004; Gray, 2004; Maxwell, Masters, & Eves, 2003), although not inspired from a dual-process perspective. For example, experienced athletes have been shown to benefit when their attention is drawn away from skill execution by a cognitively demanding secondary task or from instructions emphasizing speed when executing a skill such as a golf putt (e.g. Beilock et al., 2004), presumably because this does not allow for Type 2 processing to interfere with proceduralized skill execution and instead enables Type 1 processing to 'get the job done smoothly'.

A further, increasingly popular technique is neuronal imaging in order to correlate certain brain areas with demands of the current task. This methodology allows the investigator to identify different brain areas that are active during Type 1 processing (e.g. solving 2*4) or Type 2 processing (e.g. solving 1578*47). In this manner, it is possible to verify that some tasks require the recruitment of higher-order cognitive functions that have been empirically correlated to certain brain areas (e.g. frontal lobes) or whether they run autonomously.

The third approach highlighted by Evans and Stanovich (2013a) is termed the psychometric approach. This approach argues that a domain-general cognitive system – or capacity – exists that varies considerably between individuals. According to a recent proposal by Vogel and Awh (2008), this variability can helpfully be used to inform cognitive theory. Importantly, major progress has been made in measuring this general cognitive system by demonstrating that certain measures of WMC (Conway et al., 2005) have been successful in predicting performance in situations requiring controlled attention. According to Evans (2008, 2010) and Barrett et al. (2004), the engagement of WMC is at the core of Type 2 processing as it enables hypothetical thinking, mental simulation, and in turn decision making. Following this premise, Barrett et al. (2004) reviewed a large body of evidence linking WMC to cognitive tasks that are assumed to require Type 2 processing. This review concluded with the statement that what is controllable for one person is not so, or to a lesser degree, for another, as individuals with a higher WMC possess a superior capacity to control attention, and therefore tend to rely on this capacity. However, it is important to note that this superior capacity to control attention does not have to result in superior performance, since situations favoring autonomous Type 1 processing due to situational constraint such as time pressure might be beneficial for individuals with low WMC as they do not tend to rely on controlled processing. Of further relevance to the third approach, a line of research suggests that the ability to intentionally control attention – as in Type 2 processing – is a limited resource that gets depleted when used (see Schmeichel & Baumeister, 2010, for a review). As a result, Type 2 processing – due to its limited capacity – is no longer available to override Type 1 processing if it has been depleted by previous attention-demanding behavior.

In the next section we discuss the implications of the proposed framework for the sports domain and integrate existing research within the framework, before highlighting fruitful avenues for future research.

Dual-process theories in the sports domain

As one may imagine, successful sport performance often requires Type 1 processing as the many constraints (Davids, Button, & Bennett, 2007) of sports, such as extreme time pressure, do not allow for the effortful controlled Type 2 processing. For example, Olympic champions like Michael Phelps or Usain Bolt did not need effortful controlled attention when elegantly racing through London's 2012 Aquatic Centre or Olympic stadium. Similarly, Germany's gymnastics star Fabian Hambüchen did not have to strain his attention on the successful execution of his silver medal-winning horizontal bar routine; on the contrary, this might even disturb smooth execution as predicted by the 'paralysis by analysis' hypothesis (e.g. Baumeister, 1984; Beilock & Carr, 2001; Hardy, Mullen, & Jones, 1996; Masters, 1992).

The preceding examples highlight the involvement of the autonomous Type 1 processing and for this reason it is not surprising that a great deal of training in sports is undertaken precisely to circumvent the limitations of the slow, effortful Type 2 processing and automate behaviors (e.g. Schmidt & Wrisberg, 2004; Williams & Ericsson, 2005). However, this does not mean that *Type 2* processing is never required in sports. Recently, Toner and Moran (2014) reviewed a large body of literature and concluded that contemporary theorizing overemphasizes the autonomous nature of skilled sport performance. To illustrate their argument they cite the influential work of Dreyfus (2002, p. 372), who claimed that expert performance is executed 'without calculating and comparing alternatives … what must be done, simply is done'. We agree with Toner and Moran's criticism of this position that 'instead of relying wholly on unthinking spontaneity to guide their performance, elite athletes appear to alternate between different modes of cognitive processing' (2014, p. 1).

Type 1 processing in sports

The assumption that cognitive demands decrease with continuous practice is common in the skill acquisition literature (e.g. Anderson, 1982; Fitts & Posner, 1967; Schmidt, 1975; Schneider & Shiffrin, 1977). As skill level increases, information is restructured into a different type of skill representation, which is usually referred to as a procedure (Anderson, 1982). Retrieving procedural knowledge does not require the same amount of controlled attention as declarative knowledge, which is assumed to be involved in unpracticed skill execution in which the individual components of a skill are attended to in a step-by-step fashion. In terms of the default-interventionist framework, with ongoing practice, executing a skill relies more on Type 1 and less on Type 2 processing. For this reason, a highly practiced soccer player does not need to attend to the execution of dribbling the ball, which allows him to utilize his freed attentional resources for other aspects of the sport, such as scanning for open team-mates. Controlled attention is not only not needed for the execution of well-learned skill execution, it actually harms the smooth execution of the skill, as suggested by prominent self-focus theories (Baumeister, 1984), such as the explicit monitoring hypothesis (e.g. Beilock & Carr, 2001) or the conscious processing hypothesis (Hardy et al., 1996; Masters, 1992). In this respect, recent research has demonstrated that experienced athletes' motor skill performance benefits from dual-task demands that draw attention away from skill execution compared to dual-task demands that guide attention towards skill execution (e.g. Beilock & Gray, 2012; Beilock et al., 2004; Gray, 2004, 2011). Interestingly, this pattern is reversed in novice performers (e.g. Beilock & Gray, 2012; Gray, 2004), whose motor skill performance suffers from drawing attention away from skill execution and benefits from directing attention to the execution of the skill.

In addition, it has been suggested that certain objects or situations autonomously – i.e. using Type 1 processing – trigger a certain behavior which Gibson (1979) has termed the affordance of an object or situation. Such affordances may also include fairly complex forms of behavior, as has been demonstrated for example in sport settings (e.g. Dicks, Davids, & Button, 2010; Fajen, Riley, & Turvey, 2009). Hence, it has been suggested that affordances play an important role in efficient functioning of humans in complex environments such as sports (see Araujo, 2009, for an overview in sport), as they describe the tight coupling of the perception of the environment and action. Fajen et al. (2009) argue that this tight coupling of perception and action allows for the prospective, moment-to-moment control of movement that is characteristic of the fast-paced action on various sport fields.

Type 1 processing may also play an important role in initiating health-related behaviors (Hofmann, Friese, & Wiers, 2008). For example, many people who have formed the intention to exercise do not succeed at exercising regularly (Hagger, Chatzisarantis, & Biddle, 2002). One explanation for this phenomenon is that inactive people have learned to associate exercise with negative valence, perhaps due to negative experiences while exercising in their childhood or at school (Bluemke, Brand, Schweizer, & Kahlert, 2010). Via Type 1 processing, these negative associations may interfere with their declarative knowledge of the benefits of exercising, thus stopping them from starting to exercise. Evidence for this explanation comes from research using indirect measurements, such as Implicit Association Tests or evaluative priming tasks (e.g. Bluemke et al., 2010; Conroy, Hyde, Doerksen, & Ribeiro, 2010), which are assumed to make the results of Type 1 processing visible (Strack & Deutsch, 2004).

Despite the importance of Type 1 processing in sport and exercise-related contexts, we argue that it is not helpful to place too much emphasis on purely autonomous processes if the goal is to understand the richness and complexity of human behavior in these contexts. Therefore, we outline evidence in the next section highlighting when Type 2 processing is required or beneficial in sports.

Type 2 processing in sports

So far we have established that Type 1 processing will get the job done smoothly and efficiently in plenty of situations in sport, but in some situations Type 2 processing is required. An overemphasis of Type 1 processing in sports runs the risk of being unable to account for the flexible and dynamic nature of attentional processing among expert performers during sport competition. In this respect a recent qualitative study by Nyberg (2014) provided evidence that expert free-skiers reported deliberately allocating attention to skill execution in order to identify movement features that require adjustment. Some of the free-skiers reported that skill-focused attention is necessary to monitor their rotational velocity so that they will know whether the attempted trick will work out or whether it will need some adjustments. These statements highlight the dynamic interplay between autonomous Type 1 processing and deliberate Type 2 processing. Or as Sutton et al. (2011, p. 80) phrased it, 'we do influence ourselves in action, at different timescales and in different contexts, both as individuals and in groups, especially small groups engaged in joint action'.

A further, well-documented instance of Type 2 processing involvement is the acquisition of new skills. In an early model of skill acquisition, Fitts and Posner (1967) state that learners proceed through distinct learning phases that differ in their cognitive demands and that during early stages of learning, motor skills are attended to in a step-by-step fashion and thereby require Type 2 processing. However, skill acquisition does not always seem to require Type 2 processing as a large body of research on implicit learning (e.g. Maxwell et al., 2003) demonstrates. In line with this suggestion, Chauvel et al. (2012) were able to show that implicit motor learning stayed intact among elderly adults with age-related deteriorations in working memory, whereas explicit learning deteriorated with age and working memory decline. Hence, Type 2 processing seems to be required only when explicitly learning a new skill.

In some instances of skill acquisition, people also need Type 2 processing, when the situation demands a different behavior to that which one has become accustomed to, or when the affordance (Gibson, 1979) of a situation is not appropriate – i.e. to resolve response competition and conflict in interference situations. To provide a sport example illustrative of resolving response competition, a soccer defender anticipates that Bayern Munich's right wing player Arien Robben always feints to the outside to then cut to the center, and therefore positions himself accordingly. In this case Robben will need Type 2 processing to adapt his behavior to the demands of the situation and not rely on his habitual behavior of cutting to the center. In this respect, research shows that people with high WMC have a superior ability to control their attention, which they can use for resolving competition between competing action tendencies and action plans (see Engle, 2002, for a review). In line with this suggestion, Furley and Memmert (2012) showed that ice hockey players with a low WMC (measured with the automated operation span task; Unsworth, Heitz, Schrock, & Engle, 2005) failed to adjust their tactical decisions to the demands of the game situation and more often 'blindly' followed a tactical instruction from a virtual coach during a simulated time-out, even though it was not appropriate for the game situation. In the experimental procedure adopted by Furley and Memmert (2012), the participants were asked to make speeded tactical decisions in a computer-based ice hockey decision-making task. Critically, some of the decision-making trials were preceded by a screen simulating a team time-out taken by the coach to give the players tactical information for the upcoming offensive play. Two types of information were given in the team time-out, both concerning the goalkeeper of the opposing team. An example of an instruction given during team time-out was: 'there have been many rebounds after shots at goal as the opposing goalkeeper has difficulty holding on to the puck. Therefore, we need more long-distance shots'. At the end of the screening, participants were explicitly informed that this information should only be used if it is adequate for the game situation and they still have all decision options available. On 66% of occasions, the team time-out information was valid, that is, was followed by a game situation for which the recommended tactical decision during the time-out was the best tactical solution for the presented situation. On the other hand, on 33% of occasions, the recommended behavior during the team time-out was not the optimal decision for the subsequent situation, which instead called for a different decision (invalid trials). The ratio of valid to invalid trials was based on Kane and Engle's (2003) study, which demonstrated that WMC differences in resolving response competition are most pronounced if participants can usually rely on their automated responses (in this case following the tactical information) and only actively have to rely on controlled attention to override the prepotent response in a small proportion of trials. Importantly, ice hockey players with a high WMC were more proficient at adjusting their tactical decision to the demands of the situation instead of relying on the information they were given during a simulated team time-out that was not appropriate for the following offensive game situation. No differences between ice hockey players with high and low WMC were evident in situations in which the tactical information they received in the team time-out was helpful for the following game situation as there was no competition to be resolved, and therefore the situation did not require attentional control.

In addition, athletes need skill-focused attention when performance demands change during training or competition (Bernier, Codron, Thienot, & Fournier, 2011) or when they are confronted with performance slumps or injuries (Carson & Collins, 2011). Evidence for this line of argumentation has been provided by Collins, Jones, Fairweather, Doolan, and Priestley (2001) and Nyberg (2014), who demonstrated that expert athletes consciously modify their skill execution during performance to maintain movement proficiency. Similarly, Breivik (2007) has argued that athletes are constantly driven to learn new and better techniques. In this endeavor they may 'use reflective bodily awareness to identify "attenuated" habits in the performance context and subsequently adjust problematic movements in the training context' (Toner & Moran, 2014, p. 2). In this regard it is important to note that counteracting automaticity has been suggested to be the key to acquiring expertise (see Ericsson, 2006, for a recent review) in order to avoid arrested development and constantly push one's limits.

People also need Type 2 processing to carry out intentions or action plans, i.e. to focus attention in a goal-directed manner (for example passing the ball to a certain receiver in a predetermined offensive play in American football) while blocking out distracting information in this pursuit. Kahneman (2011, p. 36) points out that the most important capability of System 2/Type 2 processing is probably 'the adoption of "task sets" [that] can program memory to obey an instruction that overrides habitual responses'.

These task sets – e.g. instructions or self-generated intentions – are stored or activated in working memory (Kahneman, 2011). In this respect, Furley and Memmert (2013) demonstrated that the current contents of working memory direct an athlete's focus of attention, which they argue can be regarded as a central mechanism of how attention is allocated during deliberate goal pursuit. In this manner, athletes can guide their attentional system enabling deliberate goal-directed behavior.

Based on this evidence, we agree with Toner and Moran's (2014) call for a theoretical framework that can account for the dynamic nature of attentional processing during sport performance. This proposal is well aligned with the statement of Sutton and colleagues (2011, p. 93): 'Where Dreyfus pictures the context-sensitivity of expert performance as having all been set up in advance, the simple drawing forth of the appropriate option from the experienced and attuned body, we argue that genuine expertise often requires the rapid switching of modes and styles within the performance context'. In this respect we argue that the default-interventionist framework is well suited for gaining a more complete understanding of attentional processing during sports performance at varying levels of expertise.

In Table 1 we summarize the situations and circumstances that require different forms of information processing in various situations in sport. Furthermore, we list certain circumstances in sports that might not necessarily require either Type 1 or Type 2

Table 1. Situations and circumstances in which different types of information processing are required and likely to be beneficial in sports.

	Type of information processing	
	Type 1 processing	Type 2 processing
Situation or circumstance	Implicitly learning a new skill (Chauvel et al., 2012; Masters, 1992; Maxwell et al., 2003)	Explicitly learning a new skill (Fitts & Posner, 1967; Schmidt, 1975; Schneider & Shiffrin, 1977)
	Executing a well-learned skill, habit, affordance (e.g. Beilock & Gray, 2012; Fajen, Riley, & Turvey, 2009; Fitts & Posner, 1967; Gray, 2004, 2011); executing a well-learned skill while e.g. scanning for open team-mates (Abernethy, 2001).	Adjusting certain behaviors (Nyberg, 2014; Sutton et al., 2011; Toner & Moran, 2014) during training or competition (Bernier, Codron, Thienot, & Fournier, 2011; Breivik, 2007), to circumvent or come back from performance slumps or injuries (Carson & Collins, 2011; Collins et al., 2001)
	Performance stability in high-stake situations (e.g. Beilock & Gray, 2012; Beilock et al., 2004; Gray, 2004, 2011)	Intervening when an affordance, habit, or prepotent response is inadequate (Furley & Memmert, 2012)
	Context triggering behavior/ affordance (Fajen, Riley, & Turvey, 2009)	Carrying out specific tactical game plans or strategies (Furley & Memmert, 2013; Furley, Memmert, & Heller, 2010; Memmert & Furley, 2007); using cue words to maintain performance stability (Gallwey, 1997; Jenkins, 2007; Toner & Moran, 2014)

processing, but are likely to benefit from the respective type of processing as suggested by research findings. We elaborate on the practical implications of Table 1 in the following section.

Conclusion and future research avenues on dual-process theories in sport

The aim of the present review was to address an important shortcoming in the sport attention literature which Boucher (2008) pointed out by stating that attention research in sport is missing a suitable theoretical framework. In this respect the review argues that dual-process theories – and especially the reviewed default-interventionist theory (Evans & Stanovich, 2013a, 2013b) – as they relate to the working memory framework (Baddeley, 2003; Baddeley & Hitch, 1974; Engle, 2002) seem well suited to address this shortcoming. The proposed framework has both theoretical and practical implications, and offers some promising avenues for future investigations of attention research in the area of sports.

First, we argue that human movement science and motor control can benefit from taking the reviewed default-interventionist model (Evans & Stanovich, 2013a, 2013b) into account. In this regard, Baddeley (2007, p. 317) states that the study of motor performance or movement control has mainly been driven by a neo-Gibsonian approach, 'with little regard for the relevance of internal representations such as schemata, or cognitive concepts such as Shallice's SAS' (see Kelso, 1995; Shaw, 2003). Although this might be considered an overstatement concerning Schmidt's (1975) influential schema theory and its derivatives, the appeal of self-organizing theories of motor behavior is not surprising considering findings showing that it is possible to produce actions simply by stimulating certain areas of the cortex (Penfield, 1958). Similarly, it has been suggested that certain objects autonomously trigger a certain behavior, which Gibson (1979) has termed the affordance of an object. These affordances no doubt play an important role in the efficient functioning of humans in complex environments. However, affordances are not always appropriate in a given situation and therefore need to be inhibited by higher cognitive functions which are located in the frontal lobes. Hence, patients with frontal lobe damage sometimes show behavior that is excessively driven by the immediate stimulus situation. This pattern of behavior has therefore been termed utilization behavior (see Baddeley, 2007, for a review). Utilization behavior is usually part of a well-learned pattern or schema that is strongly linked to certain aspects of the stimulus situation. These findings can be accounted for by the introduced default-interventionist framework, as the frontal lobe patients miss the capability of overriding Type 1 processing by Type 2 processing when it is not appropriate in a given situation. Similarly, if athletes solely relied on Type 1 processing or the affordances of a situation, without a mechanism to override prepotent responses, they would be highly inflexible and would not be able to follow game plans, tactical instructions, or adapt their strategy towards a certain opponent. Hence, we agree with Baddeley (2007) that it is not helpful to place too much emphasis on purely autonomous processes if the goal is to understand the richness and complexity of human behavior, also in the context of sport.

Second, from a practical perspective, it is important to scrutinize how Type 2 processing can be engaged to facilitate performance without interfering. Furley and Memmert (2013; see also Desimone & Duncan, 1995) demonstrated that the current contents of working memory control the focus of attention of athletes by inducing an attentional set. This finding in sports has far-reaching practical implications as it suggests that athletes can 'load' their working memory voluntarily with certain information in order to control their attentional focus. Similarly, coaches can 'load' the working memory of athletes and thereby influence their attentional focus in a desired manner. In this review, we have repeatedly argued that various situations in sport only require Type 1 processing that operates largely without controlled attention and that well-learned skill execution is harmed by reinvesting attentional control (Baumeister, 1984; Beilock et al., 2004; Gray, 2004; Masters, 1992). Hence, 'loading working memory' with information that directs attention away from monitoring skill execution can have beneficial consequences for executing a well-learned skill (see Gray, 2011, for a recent review).

Such theorizing shows substantial overlap with the pioneering work of Timothy Gallwey (e.g. 1997) on coaching and the development of personal and professional excellence in sport and other fields. Similar to Kahneman (2011) or Evans and Stanovich (2013a, 2013b), Gallwey (1997) distinguishes two selves, with one being responsible for controlled processing and one for automatic processing. Gallwey (1997) argues in his popular 'Inner Game' publications that one self is optimized to perform the actions in sports such as tennis or golf, while the second, evaluative self has to be prevented from interfering by evaluating every action. Gallwey goes on to suggest that one self gives the instruction to the acting self, which performs the action, and gives concrete examples of how the evaluative self can help the acting self to perform the action instead of interfering. For example, when performing a tennis shot the evaluative self can give the instruction to watch the rotation of the seam on the tennis ball in order to achieve the desired goal of focusing attention on the tennis ball and thereby avoiding unwanted conscious monitoring of the shot, as research has shown that this kind of external focus of attention is beneficial for smooth skill execution (see Wulf, 2007, for a review). In addition, Toner and Moran (2014, p. 3) describe how expert sport performers use cue words as 'instructional nudges … in order to "re-route" embodied routines'. Jenkins (2007) provided evidence for this argument by demonstrating that 70% of European tour golfers used at least one 'swing thought' (i.e. a form of cue word) during on-line skill execution. Hence, Toner and Moran (2014) conclude that certain forms of mindedness or conscious processing are a common feature of elite sport performance. The attentional guidance findings by working memory as they are assumed to occur in Type 2 processing in the default-interventionist framework perfectly serve as a theoretical background for deriving these kinds of practical applications proposed by Gallwey (1997) and Toner and Moran (2014).

At present, research findings on attentional allocation during skill execution in the sport psychology literature show some contradictions that might be resolved by adopting the default-interventionist model as a meta-theoretical framework in future research endeavors. For example, some research suggests that well-learned skill execution is harmed by directing attention towards movement execution (e.g. Beilock & Gray, 2012; Beilock et al., 2004; Gray, 2004, 2011), while other research suggests that in certain situations Type 2 processing seems beneficial by monitoring skill execution online (Nyberg, 2014) or using cue words to direct attention to certain aspects of skill execution (Jenkins, 2007). Clearly, more research is needed to address these apparent contradictions in the research literature in order to gain a more complete understanding of attention in sport performance. Hence, one line of future research should establish how working memory can be optimally loaded so that it facilitates performance without interfering with performance. Moreover, we agree with Toner and Moran (2014) that future research needs to identify and establish methodological approaches to capture the attentional switching mechanisms of athletes. At present, we are not aware of any empirical research investigating the cognitive mechanisms of how athletes switch between Type 1 and Type 2 processing during training and competition. In our opinion the efficient switching between these different modes of processing constitutes an important factor in performance proficiency in sports, and has not received the research attention that it may deserve. Nevertheless, we argue that the outlined default-interventionist framework provides the necessary meta-theoretical starting point for launching this investigation.

Concluding remarks

Adopting the dual-process perspective as a meta-theoretical framework for sport psychology research could be beneficial for several reasons. First, it allows the integration of existing findings that are currently presented independently and without established connections between them. Second, it might stimulate new sport psychology theorizing as well as novel innovative experimental approaches. Third, it is possible to relate dual-process models to approaches that have existed for a long time in applied sport psychology. This is important as sport psychology is constantly challenged to empirically confirm that its interventions are effective (e.g. Gardner & Moore, 2006). However, intervention studies are difficult to conduct without an underlying theoretical basis from which strong and testable predictions can be derived. The dual-process framework has the potential to provide such a basis and, more importantly, fulfills a necessity in psychological theorizing by pitting the conscious person against the deterministic situation (Mischel, 1997).

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