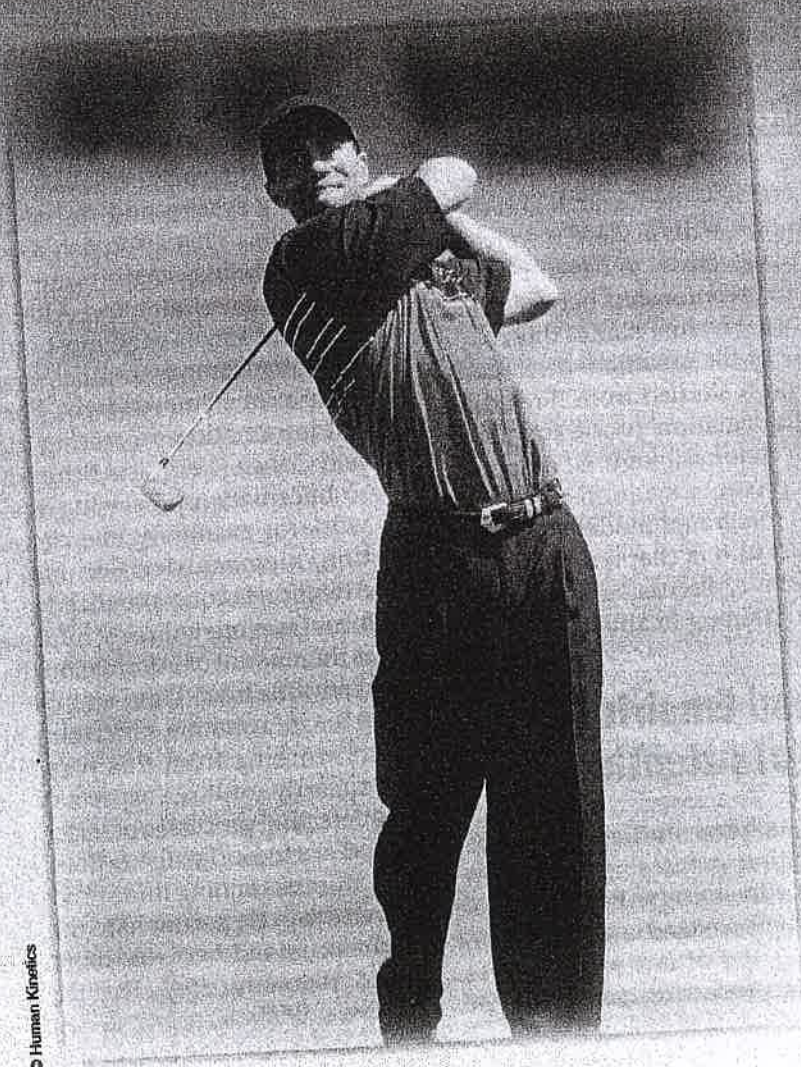


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CHAPTER 14

Attentional Processes and Sport Performance

■ Stephen H. Boutcher, PhD ■



The study of attention has a rich and varied history. In the late 1800s and early 1900s, the laboratories of Wundt, Titchener, and Helmholtz carried out many experiments examining different aspects of attention. Surprisingly, however, interest in attention waned over the next 25 years and was not rekindled until the advent of World War II. The war challenged psychologists with many applied problems concerning attention (e.g., how long could a radar operator watch a screen without a decline in attention?). Attention, currently one of the core themes in psychology, is viewed as a complex multidisciplinary field of study. According to Parasuraman (1998), research in attention is being conducted in many areas of the psychological sciences including cognitive psychology, psychophysiology, neuropsychology, and developmental psychology.

In the sport context, several authors have suggested that attention is a vital aspect of athletic performance (Abernethy, 1993; Boutcher, 1990; Moran, 1996; Wulf, 2007). The research examining the role of attention in sport, however, is underdeveloped. Furthermore, few studies have examined the attentional mechanisms underpinning athletic performance. Thus, a suitable framework to study the influence of attention on sport skills has not been established.

In this chapter I review the research and theory pertaining to attention with a view toward synthesizing various perspectives to develop a better understanding of the relationship between attention and performance. The first part of this chapter focuses on a review of the attention-performance literature as it has been studied from three different perspectives: information processing, social psychology, and psychophysiology. At the conclusion of this section I present a synthesis of the three perspectives and an integrated model of attention in sport. The last part of this chapter focuses on a more applied perspective, discussing several issues related to attentional training in athletes.

Theoretical and Empirical Perspectives of Attention

Attention in sport has been studied from three perspectives: information processing, social psychology, and psychophysiology. Each of these research thrusts has emphasized a different but related perspective of the attentional process. Research in information processing has established

the existence of two related forms of processing; control processing requires effort and is slow and cumbersome, whereas automatic processing is effortless, quick, and efficient. Social psychologists have focused on individual differences and environmental influences on attentional processes and have documented the ability of extraneous, inappropriate cues to disrupt performance. Sport psychophysiolgists have attempted to examine the underlying mechanisms of attention by monitoring cortical and cardiac activity; both cortical and autonomic indicants of attention have been used successfully to assess attentional style in athletes during performance. The following three sections discuss the relevant aspects of these approaches necessary to develop an integrated model of attention and sport performance.

Information-Processing Perspective

Cognitive psychologists consider humans to be processors of information. The information-processing approach attempts to understand the stimulus-response relationship, stimulus being some kind of information entering the body through the sensory system and response being the resulting behavior. This approach assumes that a number of processing stages occur between the stimulus and response initiation. Although the names of the different stages vary, most information-processing models include perceptual, short-term memory, and long-term memory stages. For overviews of different information-processing models, see O'Donnel and Cohen (1993) and Schmidt (1999).

Information-processing models provide a framework for examining the characteristics of perception, memory, decision making, and attention. Attention is conceptualized as the ability to switch focus from one source of information to another and as the amount of information that can be attended to at any one time. Thus, attention is a central concept in the information-processing approach. Researchers working from this perspective have focused primarily on three aspects of attention—the three interacting processes of selective attention, capacity, and alertness (Posner & Bois, 1971). Because the literature examining these processes is extensive, only those aspects pertinent to the theme of this chapter are examined here (for more complete overviews, see Abernethy, 1993; Pashler, 1998; Schmidt, 1999; Styles, 1997).

Attentional Selectivity

Selective attention refers to the process by which certain information from the internal or external environment enters the information-processing system while other information is screened out or ignored. In any situation, the organism is constantly bombarded with a mass of information from both the internal and external environments, and it can assimilate only a certain amount at a particular moment. Therefore, selection is necessary so that only a few stimuli are processed. The organism focuses on certain aspects that directly affect behavior, whereas the remaining stimuli serve as background. Selection can be voluntary or involuntary depending on whether the selection is due to the organism or to the stimuli itself. Selection can take place in a large variety of behavioral situations. That is, an individual may choose to focus inwardly on certain strategies and experiences or outwardly on a wide range of environmental cues. Thus, selection is multifaceted and appears to be an essential condition for sport performance. William James (1890) expressed this succinctly in his classical statement that "without selective interest, experience is an utter chaos."

Selective attention is believed to play a central role in both the learning and performing of sport skills. But the stimuli that are essential for a particular performance change as a function of practice and skill improvement. For example, neophytes learning to dribble a basketball must devote much attention to watching the ball and are unable to lift their heads to focus on the players around them. With practice, however, players can dribble without watching the ball, and the skill becomes more synchronized and automatic. Eventually, after many years of practice, players can dribble with either hand while simultaneously defending the ball from an opposing player and monitoring the positions of fellow players. In this latter situation, most of the performer's attention is focused externally on surrounding players rather than on the process of dribbling. In contrast, the player sent to the foul line does not have to attend to much external information. But because the foul shot is typically well learned, attention that was previously available to focus on teammates and opponents now has the potential to focus on task-irrelevant cues and internal information such as worry about missing, spectators, and so forth.

This basketball example shows that with practice, attention can be changed from a cumbersome, conscious process to a smooth, unconscious process. These two aspects of attention have been called control and automatic processing (Badgaivan,

2000; Schneider, Dumais, & Shiffrin, 1984). Control processing is used to process novel or inconsistent information and is slow, effortful, capacity limited, and controlled by the individual. In sport, control processing is involved when decisions are required. For example, a golfer who is considering distance, wind conditions, and the position of hazards to determine club selection would use control processing. In contrast, automatic processing, which is responsible for the performance of well-learned skills, is fast, effortless, and not under direct conscious control. In sport, automatic processing occurs when athletes have developed skills through many years of practice. Thus, the professional golfer uses automatic processing when swinging the club. The major differences between automatic and control processing are that automatic processing requires little effort, attention, or awareness, whereas control processing requires high awareness, much attention, and intensive effort. All sports require a combination of automatic and control processing because athletes need to perform many skills in a reflexive, automatic manner yet also must make decisions and process inconsistent cues and new information. Closed-skill sports such as golf, archery, and shooting probably require more automatic processing, whereas open-skill sports involve a combination of the two. Thus, control processing (slow, effortful, capacity limited, and controlled by the individual) and automatic processing (fast, effortless, and not under direct conscious control) have the potential to play important roles in sport performance.

Attentional Capacity

A second aspect of attention that has been examined relative to performance is attentional capacity. This term refers to the fact that control processing is limited in the amount of information that can be processed at one time. Specifically, a person can perform only one complex task at a time and thus would have difficulty focusing attention on two sources of information simultaneously. Consequently, control processing can be viewed as having a limited capacity for processing information from either the internal or external environments. Thus, performing multiple tasks or attempting to focus on more than one source of information may impair performance. An example of control processing overload in the sport context would be two coaches simultaneously giving a basketball player a stream of instructions during a time-out.

The restrictions on attentional capacity are due to both structural and central capacity limitations.

Structural interference involves two tasks performed at the same time using the same receptor or effector systems. For example, listening for the sound of a starter's gun while at the same time listening to a voice in the crowd could provoke auditory structural interference. Capacity interference occurs when two tasks compete for limited central information-processing capacity simultaneously. Fixed-capacity and undifferentiated theories represent two different views for explaining how task performance will be affected if capacity for processing is exceeded. Fixed-capacity theories (e.g., Broadbent, 1958; Keele, 1973; Kerr, 1973; Norman, 1969) assume that capacity is fixed in size and remains the same for different tasks. In contrast, theories of undifferentiated capacity (e.g., Kahneman, 1973) view attention as a resource that can be channeled to various processing operations. This approach is a more flexible view of attention and suggests that capacity changes as task requirements change. Multiple resource theory (Navon & Gopher, 1979; Wickens, 1984) is an extension of flexible attentional capacity and suggests that attention may consist of a set of pools of resources, each with its own capacity to handle information processing. This view suggests that processes requiring attention may be able to handle more than one stimulus at any one time (parallel processing). The ability of the human information-processing system to process multiple sources of information simultaneously would depend on the importance of the tasks involved, task difficulty, and structural considerations. Resource theory generally is viewed as an attractive framework for understanding attention. Critics of the theory, however, have focused on issues regarding practice and divided attention and the number of resources necessary to cover all aspects of attention (see Hirst, 1986; Logan, 1988).

Whereas control processing is fragmentized; requires much attention, effort, and awareness; and can handle only relatively simple tasks, automatic processing is just the opposite. Automatic processing requires little attention, effort, or awareness; is not serial dependent; and is holistic rather than fragmentized in nature. The capacity limitations of automatic processing are less restrictive than are those of control processing. For instance, performing a golf swing involves a variety of muscles initiated by millions of efferent neural impulses. If a person had to monitor this process consciously, the task would be overwhelming. Thus, control processing, which may be dominant in the early stages of learning (Shiffrin, 1976), eventually will give way to automatic processing if the skill is to be

performed in an effortless, efficient manner. For skill performance, then, the greater attentional capacity limitation of control processing compared with that of automatic processing is important.

Attentional Alertness

The third aspect of attention that has been examined in information-processing research concerns the effects of alertness and arousal on the breadth of the attentional field. Easterbrook (1959), in a comprehensive review of the available literature, cited numerous research studies supporting the hypothesis that increases in emotional arousal narrow the attentional field because of systematic reduction in the range of cue utilization. Landers (1980a, 1980b, 1981) used the work of Easterbrook (1959) to examine the effects of emotional arousal on athletes' visual field during performance. Numerous studies have indicated that in stressful situations, performance on a central visual task decreases the ability to respond to peripheral stimuli (Bacon, 1974; Hockey, 1970; Landers, Qi, & Courtet, 1985). Thus, it appears that arousal can bring about sensitivity loss to cues that are in the peripheral visual field. In sport, point guard play in basketball provides an example of how overarousal can affect the visual attentional field. If a point guard is looking for teammates outside the key (scanning the periphery of his or her attentional field), overarousal may bring about perceptual narrowing. This narrow focus may prevent the point guard from detecting open players in the periphery. Because many sport skills are performed in aroused states, the phenomenon of attentional field narrowing may be an important determinant of sport performance. Also the attentional narrowing phenomenon has been associated with sport injuries. For example, negative life event stress has been shown to induce peripheral narrowing that is associated with increased athletic injuries (Rogers, Alderman, & Landers, 2003; Rogers & Landers, 2005).

Conclusion

Researchers using the information perspective have focused primarily on selection, alertness, and capacity aspects of attention. Important aspects of selective attention are control and automatic processing. Control processing is slow, requires effort, and is controlled by the individual. In contrast, automatic processing is fast, effortless, and not under conscious individual control. Control processing is important in the early stages of learning and for dealing with novel and inconsistent informa-

tion, whereas automatic processing is responsible for skills that are so well learned that they require little attention or effort. Regarding alertness, it has been demonstrated that increases in emotional arousal can narrow the attentional field because of systematic reduction in the range of cue utilization. Research has also shown that the capacity limitation of control processing is more restrictive than that of automatic processing.

Social Psychological Perspectives

Because sport typically requires performance of well-learned skills, automatic processing appears to be an important aspect of athletic performance. But successful sport performance also requires use of control processing. For instance, receivers and quarterbacks must constantly monitor the environment through control processing to attend to vital cues. In these performance situations, focusing attention on task-irrelevant information while attempting to perform well-learned skills may impair performance. Social psychologists have conducted most of the research about this aspect of control processing (i.e., the possibility that task-irrelevant rather than task-relevant stimuli may enter the information-processing system, thus disrupting performance). Most theories and explanations concerning this phenomenon have evolved from research in test anxiety, self-awareness, and pain. Three areas of this attentional research are pertinent to the role of attentional control and performance of well-learned skills: distraction theories, automatic functioning, and attentional style.

Distraction Theories

Distraction theories focus on the loss of attention caused by factors that attract attention to task-irrelevant cues. Thus, if task-irrelevant cues attract an athlete's attention, performance may suffer. If an archer focuses solely on thoughts of missing the target, attention might be disrupted and performance degraded. Similarly, if a baseball or softball batter does not focus visual attention on the pitcher, he or she probably will not make contact with the ball. Thus, even momentary loss of concentration during the initial flight of the ball may have devastating results.

One factor that may divert attention to irrelevant stimuli is worry. Sarason (1972) and Wine (1971)

suggested that worry as an emotional state distracts attention and thus can explain the negative effects of test anxiety on performance. According to Sarason and Wine, anxious people typically focus their attention on task-irrelevant thoughts and ignore critical task cues during testing. Thus, individuals who dwell on thoughts such as "I know I'll fail because I'm not as good as the others" are not focusing their attention on task-relevant cues and will not produce performance results that reflect their ability. Acute anxiety, in the form of self-debilitating thoughts, has been associated with competitive athletic situations (Gould, Greenleaf, & Krane, 2006). Thus, this research on distraction seems to be especially relevant to the study of sport. Processing task-irrelevant information can explain performance decrements in a wide range of athletic settings. In highly competitive situations, for example, performance could be hampered because the athlete focuses on self-defeating thoughts. In contrast, in nonstimulating, low-arousal environments (e.g., competitions that occur over hours or days), a lack of intensity in attention may cause the athlete to miss important task-relevant cues.

Another source of distraction information is self-awareness. Carver and Scheier (1981) suggested that attending to oneself while performing may take attention away from task cues, thus degrading performance. Other authors (Duval & Wicklund, 1972; Scheier, Fenigstein, & Buss, 1974) have suggested that attending to oneself and to the environment at the same time is impossible. Because social facilitation generally tends to increase self-awareness (Carver & Scheier, 1978), the presence of spectators and cameras at sporting events has the potential to increase focus on the self, thus distracting the athlete. Thus, distraction in the form of worry or self-awareness is another attentional factor that can affect skill performance.

Automatic Functioning

The second area of study in the social psychology research literature that is relevant to the disruptive effects of inappropriate attentional focus concerns the automatic execution of sport skills. This concept relates to the automatic-processing idea that was discussed in the section on information processing. Baumeister (1984) suggested that competitive pressure makes people want to do so well that they tend to focus on the process of performance. In competitive situations, when individuals realize the importance of correct skill execution, they attempt to ensure success by consciously monitoring the

process of performance. That is, they attempt to put the execution of a skill, which is typically under automatic-processing control, under the control-processing mechanism. Unfortunately, consciousness (control processing) does not contain the necessary information regarding the muscle movement and coordination essential for effective performance. Thus, attempting to exert active or conscious control over the process involved in a skill can degrade performance (Kimble & Perlmuter, 1970). An example of the effect of consciously controlling well-learned skills was provided by Langer and Imber (1979), who demonstrated that attempting to ensure accuracy by consciously monitoring finger movements during typing was detrimental to performance. Keele (1973) found that focusing attention on hand movements during piano playing detracted from performance. Krings et al. (2000), using magnetic functional imaging, also found that professional compared to amateur piano players exhibited less cognitive effort during performance. Baumeister (1984) demonstrated this effect by using laboratory tasks when he found that increasing subjects' attention to the process of performing debilitated performance. Thus, attempting to ensure success by consciously monitoring performance during competition is another inefficient use of attention.

Attentional Style

Individual differences may exist regarding the distraction and automatic-processing concepts discussed in the previous sections. Thus, in competitive situations, certain athletes might use an attentional style that hinders performance. Variations in attentional style and their effect on sport performance have formed the focus of much of the attentional research in sport psychology. For instance, Nideffer (1976b), using concepts developed by Easterbrook (1959), Wachtel (1967), and Bacon (1974), suggested that the attentional demands of any sporting situation will vary along two dimensions: width (broad or narrow) and direction (internal or external). A broad external focus requires people to focus on a wide area of the external environment (e.g., a quarterback scanning the width of the field), whereas with a broad internal focus, people focus attention internally on a variety of strategies and past experience. A narrow external focus is appropriate for activities that require people to focus on a narrow aspect of the external environment, such as a golf ball or the ring in foul shooting. A narrow internal attentional focus is most suited to attending to specific images or cognitive cues.

The challenge for the athlete, according to Nideffer, is to match the attentional demands of the sporting environment with the appropriate attentional style. Therefore, an individual who uses an inappropriate style for a particular activity (e.g., a baseball batter who broadly focuses his attention on players and spectators rather than using a narrow focus on the pitcher) may experience impaired performance. Nideffer (1976b) also used Easterbrook's notion of attentional narrowing to explain the effects of anxiety and arousal on attentional processes. As discussed previously, the suggestion is that arousal produces an involuntary narrowing in attention and may interfere with the person's ability to shift attentional focus.

Nideffer (1976b) proposed that individuals may possess a particular attentional style. These styles, which are relatively stable across situations and over time, may affect performance in certain situations if the athlete's style is incompatible with the attentional requirements of that situation. For example, a basketball player may consistently focus on thoughts of missing when shooting foul shots. In contrast, the aspects of attention that are state dependent are situation specific and thus are amenable to change. Nideffer (1976b) developed the Test of Attentional and Interpersonal Style (TAIS) to assess the strengths and weaknesses of an individual's attentional style. The subscales of the TAIS are broad external, external overload, broad internal, internal overload, narrow effective focus, and errors of underinclusion. Although Nideffer provided preliminary support for the reliability and validity of the TAIS (Nideffer, 1976c), more recent research has suggested that the TAIS has limited validity and predictive properties for sport performance. Landers (1981, 1985a), who reviewed research examining the TAIS and sport performance, concluded that the scale seems to measure the narrow versus broad dimension but not the internal versus external dimension. Furthermore, he found no evidence that the TAIS is a good predictor of sport performance. Other researchers have developed sport-specific versions of the TAIS for tennis (Van Schoyck & Grasha, 1981) and baseball (Albrecht & Feltz, 1987) in an attempt to increase the reliability and validity of questionnaire assessment of attentional style. Although these versions of the TAIS increased internal consistency and were better predictors of performance, the prediction-performance relationship was still weak.

Any questionnaire assessment of attention is inherently limited in at least two ways. For instance, the assumption underlying questionnaire assess-

ment is that athletes are able to make accurate assessments of their attentional focus across varying situations. The veracity of this assumption has not been established. Second, the assumption that self-analysis and language can accurately describe attention has problems. As discussed earlier, the automatic-processing aspect of attention appears to be free of conscious monitoring (Schneider et al., 1984). Thus, a paradox may exist when athletes are asked to assess nonconscious attentional states by way of conscious processing.

A related aspect of attentional style is the association-dissociation attentional strategies that elite and nonelite marathon runners use. Exploratory interviews with such athletes (Morgan & Pollack, 1977) have revealed that elite runners were less likely to use dissociative strategies when running (focusing on distractive thoughts to divert attention from physical discomfort) than were nonelite runners. Rather, elite marathoners reported that they used associative strategies (focusing on bodily sensations such as breathing and feelings in legs) more often than did nonelite runners.

Schomer (1986) suggested that postinterview data, postrace questionnaires, and anecdotal reports do not accurately assess the continuous thought flow of runners while running. To test this suggestion, Schomer (1986) used a tape recorder to record runners' thoughts while they ran on a treadmill. The tapes were then content analyzed by coding thoughts into mental strategies. From this analysis, 10 categories emerged as mental strategy subclassifications. Comparison of elite and nonelite runners' use of the 10 categories did not support the results of Morgan and Pollack (1977), who found that elite marathoners used associative mental strategies, whereas non-world-class runners preferred to dissociate. In contrast, the results of the Schomer study suggest that regardless of the marathon runners' status, increased running pace was accompanied by a predominately associative mental strategy.

In a second study, Schomer (1987) trained marathon runners to use associative thinking. A five-week mental strategy training program taught nonelite marathon runners to use associative thought processes similar to those of superior marathon runners. Eight of the 10 marathon runners undergoing the program exhibited increased associative thought processes and an increase in perceived training effort. Schomer concluded that using associative mental strategies during marathon running and training might enable athletes to achieve optimum running threshold. Overall, these results suggest that an associative attentional

focus may be most beneficial for long-distance sporting events such as marathon running. Acute (e.g., cycling on a stationary bike for 20 minutes) and chronic exercise (e.g., walking three times per week for 40 minutes) have also been found to influence certain aspects of attention. Overall, results indicate that moderately vigorous aerobic exercise lasting up to 60 minutes enhances cognitive function but that extended exercise reduces information-processing efficiency. Reviews in this area include the effect of acute exercise on cognitive ability of adults (Brisswalter, Collardeau, & Arcelin, 2002; Tomporowski, 2003) and the effect of chronic exercise on cognitive ability of older adults (Colcombe & Kramer, 2003).

Social psychologists' interest in attention has focused primarily on the disruptive influence of nonrelevant task stimuli such as worry and self-consciousness. In well-learned tasks, inappropriate use of control processing appears to have the potential to hamper the performance of well-learned skills that are typically under the control of automatic processing. In sport, in which many skills are well learned, athletes may interfere with automatic non-conscious performance by focusing on distracting information such as worry and fear of failure and by consciously attempting to control movement.

Social psychologists also have been interested in potential individual differences in attentional capabilities. These differences in attentional style of different athletic groups have been assessed through questionnaires. The rationale behind such questionnaires is that assessment of an athlete's attentional style can predict future performance. Unfortunately, no evidence exists that attentional questionnaires are good predictors of sport performance. Also, because of the nature of automatic processing, the validity of assessing attentional states by retrospective recall is uncertain. Other ways of assessing attentional style include interviews and thought-sampling techniques. The latter strategy may have greater potential for attentional assessment because it does not rely on retrospective recall.

Psychophysiological Perspectives

In contrast to cognitive psychologists who have attempted to understand attention by studying the whole process (receptor, information processing, and motor output), psychophysiologicals have attempted to identify the mechanisms of attention

by examining its component parts. In psychophysiological research, electroencephalogram (EEG), evoked response potentials (ERPs), heart rate, and gaze behavior primarily have been used to examine attention and its relationship to performance. For instance, EEG (obtained by monitoring general cortical activity through scalp electrodes) has been studied in relation to a variety of cognitive tasks including vigilance detection, perceptual structuring, and object recognition and discrimination. ERPs, which are averaged brain responses to a series of stimuli, also have been examined as indicants of attention and have been found to be sensitive to the level of concentration on a task.

Psychophysiological indicants of attention also have been used in sport research. Hatfield, Landers, and Ray (1984), for example, examined left and right brain alpha EEG activity of elite rifle shooters while subjects were shooting and while they performed a series of mental tasks. Results indicated that progressive electrocortical lateralization occurred toward right hemispheric dominance before the trigger pull. Thus, seconds before pulling the trigger, shooters exhibited more alpha activity in their left hemisphere compared with their right. The authors suggested that elite shooters may possess such a high degree of attentional focus that they can effectively reduce conscious mental activities of the left hemisphere, thus reducing cognitions unnecessary to performance of the task. This cognitive efficiency phenomenon found in shooting is a robust finding because a series of recent studies have replicated it (Deeny, Hillman, Janelle, & Hatfield, 2003; Haufler, Spalding, Santa Maria, & Hatfield, 2000; Janelle, Singer, & Williams 1999; Kerick, Douglass, & Hatfield, 2004; Kerick et al 2001).

Crews and Landers (1992) found similar decreases in left hemispheric alpha EEG activity immediately before golfers struck the ball when putting. Unlike shooters, however, golfers showed decreased right hemispheric alpha activity before putting. The authors suggested that the different EEG responses during putting may be caused by the need for both hands to be actively involved in putting.

Landers et al. (1994) showed that as novice archers improve performance, their EEG asymmetries change to resemble those of elite archers. These authors found that left hemisphere alpha activity of novice archers before releasing the arrow increased as archers improved performance. An extreme increase, however, was associated with poorer performance. Also, after the 15-week archery class, heart rates of the novice archers were observed

to decelerate seconds before shooting. The authors concluded that EEG asymmetries and heart rate deceleration are markers of attention that change with learning.

Other sport scientists have examined ERPs before and during shooting. In this research, investigators record multiple ERPs and then separate them from other electrocortical noise by signal averaging techniques. For example, Konttinen and Lyytinen (1992) and Konttinen, Lyytinen, and Konttinen (1995) examined an ERP known as slow wave. They found that increases in frontal negative shifts were associated with successful performance if central-right slow waves were more positive than central-left slow waves. The authors suggested that the results reflected the ability of elite shooters to eradicate irrelevant motor activity while concentrating on visuospatial processing.

These data support the notion that there are general processing differences between the left and right cerebral hemispheres of the brain. For example, studies of split-brain patients' performance (LeDoux, Wilson, & Gazzaniga, 1977; Sperry, 1968) and EEG patterns (McKee, Humphrey, & McAdam, 1973) and lateral eye movements (Schwartz, Davidson, & Maer, 1975; Tucker, Shearer, & Murray, 1977) have demonstrated that for most people, verbal and linguistic processing occurs in the left cerebral hemisphere, whereas spatial cognitive processing occurs in the right hemisphere. Also, the left hemisphere appears to process information analytically, breaking down a concept into discrete parts, whereas the right hemisphere processes holistically in a gestaltic fashion (Springer & Deutsch, 1998; Tucker et al., 1977).

Another variable that has been used to explore attentional states in athletes is cardiac deceleration. For example, a number of studies have found heart rate deceleration with elite rifle shooters just before the trigger pull (Helin, Sihvonen, & Hanninen, 1987; Konttinen & Lyytinen, 1992; Landers, Christina, Hatfield, Doyle, & Daniels, 1980). Similar results have been found with archers, who exhibited a progressive deceleration in heart rate seconds before the release of the arrow (Landers et al., 1994). But another study of elite archers did not find heart rate deceleration before arrow release (Salazar et al., 1990). The authors explained the absence of heart rate deceleration in their elite archers because of the physiological strain imposed when drawing a 14- to 22-kilogram bow. They concluded that cardiac deceleration can be used as an attentional index only when the preparatory state is not physiologically demanding.

Boutcher and Zinsser (1990) also found similar deceleration effects with elite and beginning golfers on a putting task. Both groups displayed heart rate deceleration during performance of 4- and 12-foot (1.2- and 3.6-meter) putts, although the elite golfers showed significantly greater deceleration. The elite golfers also possessed significantly less variable preshot routines. The authors suggested that the different heart rate deceleration patterns may reflect the more efficient attentional control of the elite golfers. Other researchers who examined old and young golfers found similar results (Molander & Backman, 1989).

Gaze behavior is another measure used to examine attention and sport performance. Gaze behavior is believed to represent visual attention organization during closed-skilled performance (Vickers, 1996a) and has typically been measured by video-based eye movement systems (Janelle et al., 2000). Vickers (1996b) has shown that the quiet eye period, defined as the duration between the final fixation to a target and the initiation of the motor response, is a major performance determinant among expert and novice free-throw shooters. Highly skilled free-throw shooters recorded significantly longer quiet eye periods before performing a free throw compared with less skilled players. Vickers (1996b) suggested that the longer the gaze is fixated on the target (the quiet eye period), the more optimal is the preparatory period. The quiet eye phenomenon has also been shown to be characteristic of elite volleyball players (Vickers & Adolphe, 1997) and expert small-bore rifle shooters (Janelle et al., 2000).

Sport psychophysiologicals have studied attention by monitoring cortical and autonomic responses during athletic performance. EEG studies have indicated that elite shooters display cortical lateral asymmetry during shooting performance. Cardiac deceleration has been associated with attentional states in archery, shooting, and putting. Eye gaze has been shown to influence the preparatory period in sports such as basketball, volleyball, and rifle shooting.

Synthesis of Theoretical Perspectives

The review of the research and theory presented in the first half of this chapter has revealed that the attention-performance relationship has been studied from three different viewpoints. Despite the relatively diverse nature of these three perspectives,

they actually represent complementary approaches and together provide a unique, integrated perspective on the relationship between attention and sport performance. Therefore, I recommend that future research into the attentional processes underlying athletic performance take into account the principles outlined in the previous sections on information processing, social psychology, and sport psychophysiological research. Thus, attention should be viewed as a multifaceted, multilevel phenomenon that can be assessed through questionnaires, thought sampling, observation analysis, performance, and psychophysiological measures. The appropriateness of the measure would depend on whether the performer carries out the skill in the control-processing mode or the automatic-processing mode. Other factors that need to be considered when investigating the attention-performance relationship include individual differences, environmental influences, and changes in the performer's level of arousal. A preliminary framework based on this multidimensional approach is illustrated in figure 14.1. This proposed model integrates relevant aspects of the research and theory on attention from all three perspectives. As shown in figure 14.1, enduring disposition (e.g., high trait anxiety), demands of the activity (e.g., putting versus sprinting), and environmental factors (e.g., spectators and television cameras) initially will determine the level of physiological arousal of the individual. During task performance, the individual could channel this arousal into control processing, automatic processing, or a combination of both. The nature of the task would determine the appropriateness of using either control or automatic processing. The individual would achieve an optimal attentional state, then, by reaching or attaining the exact balance of control and automatic processing essential for that particular task. Obviously, disruption in attentional processes would occur if internal or external factors caused the individual to reach a level of arousal that would cause an imbalance in control and automatic processing.

The arrows linking the ellipses and boxes in figure 14.1 indicate feedback mechanisms that would allow factors to interact and influence attention both during and after performance. An example of the interaction of these factors is a golfer attempting to hole an important putt. The perceived importance of the putt (e.g., a putt to win a tournament) could increase physiological arousal and anxiety, which, in turn, could reduce the golfer's attentional capacity. This anxiety could generate thoughts of missing the putt, which could direct attention away from

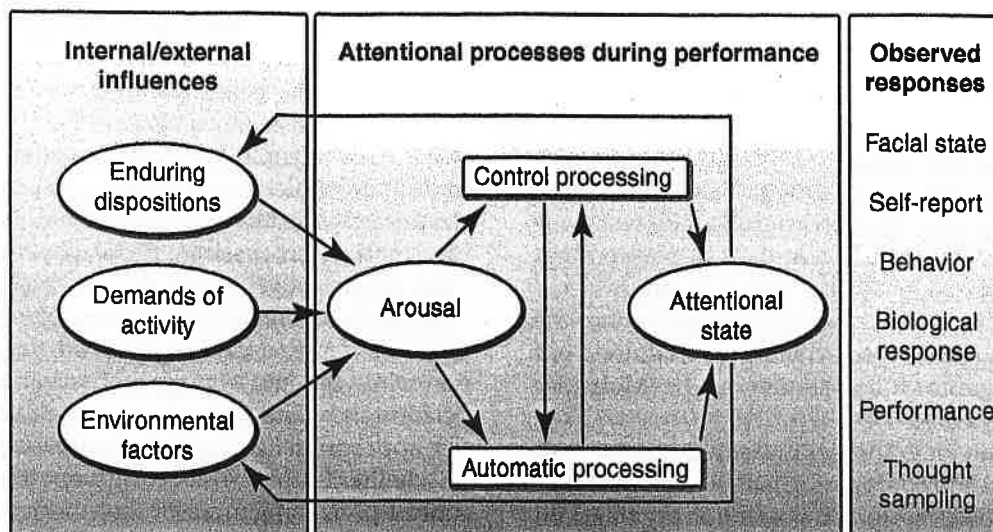


Figure 14.1 Interactions between internal and external factors and attentional processing.

task-relevant cues. Thus, the golfer may focus attention mostly on irrelevant information and be primarily in the control-processing mode. This state may be detrimental to putting performance, which the golfer should probably perform in the automatic-processing mode.

Possible ways to measure either control or automatic processing are illustrated in the end column. Self-report may be most useful for people engaging in control processing, although this notion does not preclude the use of retrospective recall to assess feelings and emotions associated with automatic processing. Variables such as facial state, eye gaze (discussed further in the next section), and psychophysiological variables also appear to have potential for measuring attention during athletic performance.

In summary, researchers who study the relationship between attention and performance need to consider integrated models of attention. Viewing attention from a multidimensional perspective may generate more systematic research and provide a more reliable and valid research paradigm.

Applied Perspectives on Attentional Control

As shown in this review, attentional theories of sport performance are not well developed. In addition, the empirical research that has been conducted on attention in sport has lacked a unifying model. Consequently, techniques to improve athletes' atten-

tional capabilities have not been developed within a theoretical framework and have proceeded largely by trial and error. Certainly, applied research needs to be conducted to advance understanding of how athletes' attentional capabilities can be improved. Specifically, qualitative strategies (e.g., single-subject research) should be wedded to the idiographic framework suggested earlier.

Given the lack of empirical research on attentional training, sport psychologists who want to provide attentional training for individual athletes will need to develop programs based on the research and theory discussed previously. The purpose of this last section is to outline a preliminary attentional training program. This proposed training program is based on the research and theory described in the previous sections. These recommendations are consistent with the principles outlined in the integrated model illustrated in figure 14.1. Considerably more field research, however, is needed to test the suitability and efficacy of these proposed techniques. This final section is divided into three parts: assessment of athletes' attentional strengths and weaknesses, basic attentional training, and advanced attentional training.

Assessment of Attentional Strengths and Weaknesses

Before an attentional training program can be designed and conducted for an individual athlete, an assessment of the athlete's attentional strengths and weaknesses will be necessary. Given the multifaceted nature of attention, it follows that assess-

ment strategies will be most effective if they are also multifaceted. Some possible ways to assess an individual's attentional capabilities include questionnaires, interviews, thought-sampling techniques, observational analysis, performance tests, and psychophysiological measurement. These assessment strategies are examined further in the following paragraphs.

Sport-specific questionnaires seem to be more reliable and predict more variance associated with performance than do general measures of attention (Zaichowsky, 1984). As discussed previously, sport-specific forms of the TAIS have been developed for tennis (Van Schoyck & Grasha, 1982) and baseball (Albrecht & Feltz, 1987). These questionnaires should be used with caution, however, and only as one part of a multidimensional assessment of attention because of their inherent limitations, which were discussed previously. The thought-sampling technique (Klinger, 1984; Schomer, 1986) appears to be a more valid way of assessing what athletes focus their thoughts on during performance. This technique involves recording individuals' thoughts during actual activity (usually by tape recorder); it seems especially appropriate for continuous activities such as running but could be adapted to other sports. For instance, golfers could record on a tape or write on a scorecard (see Boutcher & Rotella, 1987) their thoughts and feelings after shots. The researchers could then perform content analysis and estimate attentional foci during task performance.

Athletes' attentional strengths also could be measured through laboratory tasks such as choice reaction time tasks, the Stroop test, and the grid test. For instance, in research with elite and nonelite archers, Landers, Boutcher, and Wang (1986) found that the better archers recorded lower reaction times when performing a reaction-anticipation time task than did their lesser-skilled counterparts. Better archers' lower reaction times were due to greater consistency across performance trials, not because they were innately faster. Thus, these elite athletes' responses may have been more consistent because they could concentrate more effectively in this testing situation. Whether this difference in concentrational capabilities is linked to actual performance differences between elite and nonelite archers has not been established.

Another laboratory task that could be used to assess attentional capabilities is the Stroop test (Stroop, 1935). This test involves watching a series of slides flashed on a screen at the rate of one per second. On each slide is a word of a color in a contrasting color. For example, the word *red* may appear

in green letters. Participants are required to report the color of the letters rather than the word. This task has been used extensively in a variety of research areas and usually produces heart rate increases of approximately 10 to 20 beats per minute. The task requires people to learn to focus attention on the color aspect of the slide while ignoring the letters. Stroop performance could be collected and used to assess both the efficacy of the Stroop as a training strategy and the efficacy of other attentional techniques. The grid test is another task that has been used with athletes (Schmidt & Peper, 2001). This test involves checking off random numbers on a sheet as quickly as possible in a one-minute period. This test is administered easily and requires little equipment. As discussed in the section on advanced attentional training, other more sport-specific attentional strategies involving computers and videos could be used after initial experience with these laboratory tasks.

Another form of attentional assessment involves the use of observational behavioral analysis. Crews and Boutcher (1987) developed an observational analysis technique that they have used to assess the consistency of professional golfers' preshot routines. In a series of studies, they found that elite golfers possessed more consistent preshot routines than collegiate or beginning golfers did (Boutcher & Crews, 1987; Crews & Boutcher, 1986). Thus, behavioral analysis through observation or videotaping appears to be an effective way of examining the behavioral concomitants of attention during actual performance.

Another potential indicant of attention is the assessment of facial or eye states. A well-developed body of literature has examined facial reactions as an indicant of affective states (Camras, Holland, & Patterson, 1993; Ekman & Friesen, 1975; Izard, 1977; Tomkins, 1983), although facial reactions associated with attentive states do not appear to have been examined. Similarly, the direction and characteristics of eye gaze have not been tested with regard to athletic performance. Facial responses and eye gaze, however, may reflect the general control and automatic-processing styles discussed earlier. For instance, Tucker et al. (1977) characterized an individual's hemispheric usage by observing lateral eye movements. As discussed previously, research has established that most people perform verbal and linguistic processing in the left hemisphere of the brain and perform spatial cognition and perception in the right hemisphere. Kocel, Galin, Ornstein, and Merrin (1972) suggested that people who are responding to a question will tend to

look left if the response requires spatial thinking and right if the question requires verbal thought. Thus, lateral eye movement to different types of questions may indicate primary activation of the contralateral hemisphere. Although this lateral eye movement assessment has not been used in sport, research in cognitive behavioral therapy suggested that cognitive behavioral methods were most effective if they employed cognition of the participants' nonpreferred hemisphere (Tucker et al., 1977). Consequently, it may be possible to characterize athletes as to their primary patterns of hemispheric usage based on the frequency of leftward and rightward eye movement when responding to different types of sport-related questions.

Psychophysiological indicants of attention also could be used to assess attention. Equipment to collect indicants of attentional style is becoming cheaper, more portable, and easier to use. Several companies offer relatively inexpensive, user-friendly biofeedback systems that can collect a host of physiological variables. Thus, EEG, heart rate, pulse amplitude, respiration, EMG, skin temperature, and other physiological variables can be either used in a biofeedback setting or stored for research or applied purposes. Autonomic indicants of attention such as heart rate are less affected by movement and, therefore, lend themselves to collection during actual performance. For example, wrist telemetry monitors (Polar heart watches) can record up to 24 hours of heart rate during actual athletic performance. The data can then be downloaded to a computer and displayed graphically. Because cardiac patterns seem to be associated with attentional style (Boutcher & Zinsser, 1990; Crews & Landers, 1992), this variable seems to have potential for assessing cognitive activity during performance.

Finally, techniques to assess the attentional demands of sporting situations also need to be developed. As Nideffer (1976a) pointed out, athletes need to match the attentional demands of the sporting environment with the appropriate attentional style. Thus, the athlete's attentional strengths and weaknesses should be assessed and compared with

the attentional demands of the particular sport. Table 14.1 illustrates some of the factors that need to be considered when analyzing the attentional demands of an individual position in a particular sport. Open-skill activities involve continuous and repetitious movement patterns (e.g., swimming or basketball), whereas closed-skill activities are of a stop-and-start nature (e.g., golf or archery). Fine skills require accuracy and generally involve more delicate movements (e.g., putting or dart throwing), whereas gross skills are more dynamic and involve larger muscle groups (e.g., sprinting). Generally, athletes performing fast, gross, open-skill sports are less prone to sources of distraction because attentional capacity is more limited during performance. In contrast, performers participating in closed-skill activities may be more susceptible to disruption of attention because of the extra time and capacity available.

This section has described possible ways to assess an individual's attentional capabilities. Techniques include questionnaires, interviews, thought-sampling techniques, observational analysis, performance tests, and psychophysiological measurement. A method to categorize the attentional demands of different sports was also described.

Basic Attentional Training

Based on the multidimensional profile that can be obtained from the assessment of an athlete's attentional capabilities, a training program could be designed around the athlete's attentional strengths and weaknesses. If basic attentional training is required, the program would start at a basic level and gradually progress to more complex, sophisticated attentional skills. But whether attentional training on laboratory or nonsport tasks will transfer to athletic performance is not clear. Considerably more research needs to be conducted to assess the generalizability of attentional training as well as other forms of training (e.g., relaxation and imagery). Nevertheless, there appears to be potential in viewing attentional skills in a similar fashion

Table 14.1 Nature of Sport Skills and External Demands

Nature of the task	External factors	Attentional processing
Slow-fast	Game demands	Control processing
Open-closed	Environmental demands	Automatic processing
Fine-gross	—	Combination of control and automatic processing

to motor skills in which the learning environment is most productive if structured in a graduated fashion (Cote, Baker, & Abernethy, 2003). Thus, attentional training on laboratory tasks such as the Stroop, reaction time, and grid tests could form the first phase of the attention-training program, with training on more sport-specific skills conducted in later phases.

Besides the laboratory training tasks already identified, biofeedback is another technique that can be used to develop basic attentional skills. Biofeedback requires people to be able to self-monitor and eventually control autonomic and somatic responses by interacting with some form of feedback loop (usually a computer). Thus, athletes can practice basic attentional control by learning to focus their attention on a variety of biofeedback cues. When athletes are directed to watch the screen or listen to an auditory cue, their attentional efficiency could be assessed by monitoring the resultant effects on the physiological variables being used. Because biofeedback reinforces the subject, this type of training task gives instant feedback to the person about his or her ability to focus and adjust to the appropriate cue.

Thus, basic attentional training programs could be structured around a variety of laboratory tasks and organized so that attentional tasks become progressively more difficult. Through these types of training activities, athletes could attempt to acquire basic control of variables such as heart rate, respiration, and attentional focus.

Advanced Attentional Training

An extension of basic attentional training may take the form of a sport-individualized program. At this advanced phase, the first step should be verification that the athlete has acquired basic attentional control and is ready to develop sport-specific attentional skills. For closed-skill athletes, much of the initial work at the advanced attentional training level needs to focus on the development of sound, effective preperformance routines (Boutcher, 1990; Moran, 1996). Thus, the precursor to successful attentional control during actual performance may be the establishment of a series of behavioral, physiological, and cognitive cues, which optimally prime both body and mind for the ensuing skill.

Although an increasing number of researchers are examining preperformance states, little research has explored attentional states during actual athletic performance. This lack of inquiry is probably due to the general reluctance of cognitive psychologists to

examine processes that are not readily available to conscious processing. Consequently, unconscious or subconscious processing has been confined largely to psychodynamic theory and has remained relatively unexplored in cognitive psychology (Kissin, 1986). In sport, optimal attentional states have been labeled peak performance (Privette, 1982; 1983) or flow states (Csikszentmihalyi, 1975; Jackson, 1996). Unfortunately, these states have been mainly assessed through retrospective self-report of athletes. This approach views optimal attentional functioning as an outcome rather than a process and does not tell us much about the underlying process (Hatfield & Landers, 1983). Thus, an outcome approach may not be helpful in designing programs to improve attentional flow during performance.

A tentative hypothesis based on the concepts of control versus automatic processing and left versus right brain functioning, which were discussed earlier, may help stimulate research into the process of attentional flow. As noted earlier, previous research has demonstrated that elite shooters exhibit patterns of left and right brain cortical activity different from those of less elite shooters (Hatfield & Landers, 1983; Kerick et al., 2004). Specifically, the elite shooters showed suppressed left hemisphere activity and enhanced right brain activity. This particular pattern may represent the optimal attentional state during automatic skill execution. Furthermore, because performing in competitive environments is likely to generate physiological arousal (Moran, 1996), attentional flow may be achieved when physiological arousal is channeled into automatic processing rather than control processing. Thus, focusing attention on the task at hand when physiologically aroused may increase attentional flow. Because arousal tends to focus and narrow attention (Easterbrook, 1959), increased arousal and task-appropriate processing may generate the positive emotion, focused attention, and oneness with the task that are associated with attentional flow states (Jackson, 1996). Thus, the athlete who directs arousal away from task-irrelevant information and into the task itself may create optimal attentional flow. This relationship is diagrammed in figure 14.1. Consequently, the challenge for the athlete or any other performer may be to learn how to direct competition-generated arousal into automatic processing of the task at hand while suppressing analytical processing. Thus, athletes who are actively thinking of "nothing" while allowing themselves to perform skills reflexively and automatically may be using the most efficient attentional style for performing in competitive, challenging situations.

Because a large body of research indicates that brain-wave activity can be self-regulated, sport-specific EEG biofeedback seems to be of value in teaching athletes appropriate attentional focus during performance. For instance, research has established that people can learn to suppress cortical activity by learning to enhance alpha waves (Bauer, 1976; Elder et al., 1985; Jackson & Eberly, 1982). Other studies have demonstrated that participants can self-regulate EEG activity. For example, Schwartz, Davidson, and Pugwash (1976) trained participants to develop both symmetrical and asymmetrical EEG patterns. Suter, Griffin, Smallhouse, and Whitlach (1981) also found biofeedback control of EEG asymmetries.

In the sport context, one study has examined the effect of brain-wave biofeedback on archery performance. Landers et al. (1991) administered right hemispheric alpha feedback, left hemispheric alpha feedback, or no feedback to three groups of archers. The left hemisphere group improved performance, whereas the right hemisphere group exhibited significantly worse performance.

Although the efficacy of these EEG biofeedback techniques has yet to be established in sport, the increasing use of biofeedback in a variety of athletic situations (Landers, 1985b) suggests that this technique has potential. For example, biofeedback techniques could be combined with sport-specific videos. Thus, the athlete could be trained to produce the appropriate attentional focus while participating in a video experience of the sport. Progressing from the video to sporting situations on the practice ground and then eventually to the actual competitive setting appears to be logical. But research is clearly needed to establish the efficacy of these techniques in the sport domain.

Exploration of applied aspects of attentional control in sport is only beginning. Many of the ideas and suggestions expressed in this section are speculative and unsubstantiated by empirical research. My intent was not to provide the reader with untried techniques but rather to provide a broad review of

potential strategies that need to be investigated. I hope that this attempt to synthesize related research in attention to applied interests in sport will generate both basic and applied investigations into the attention phenomenon.

Conclusion

In this chapter I have attempted to integrate research examining different aspects of attention from the areas of information processing, social psychology, and psychophysiology. Each of these research thrusts has emphasized a different but related perspective of the attentional process. Research in information processing has established the existence of two related forms of processing. Control processing requires effort and is slow and cumbersome, whereas automatic processing is effortless, quick, and efficient. Social psychologists have focused on individual differences and environmental influences on attentional processes. The ability of extraneous, inappropriate cues to disrupt performance has been established. Sport psychophysiologicalists have attempted to examine the underlying mechanisms of attention by monitoring cortical and cardiac activity. Both cortical and autonomic indicants of attention have been used successfully to assess attentional style in athletes during performance. I outlined a preliminary model encapsulating these principles. This multileveled, multifaceted nature of attention was developed further in the applied section, and I described a variety of assessment and training strategies. Assessment strategies included questionnaire, performance, thought-sampling techniques, behavioral analysis, and psychophysiological indicants. I outlined a preliminary model of attentional flow during peak performance and then described training strategies to enhance attentional abilities, including performance tests, computer and video tasks, and biofeedback strategies.