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Transient Hypofrontality Hypothesis and Flow Experience

Doctoral Thesis

For Attaining of Degree (Dr. phil.)

by

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For my family, my husband „Ahmed“, and

my loving children „Hosam, Hesham and Lara“

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Problem and Objective of Study

Psychopedagogy of Physical Education supplies specific scientific information, such as the flow experience and its positive affect during learning, exercise pedagogy, body movement-controlled games and performance was studied and discussed (Jackson et al., 2001; Lloyd & Smith, 2006; Camacho et al., 2008; González-Cutre et al., 2009; Schüler & Engeser 2009; Thin, 2011).

Another interactive scientific field is Psychobiology of Physical Activities, which supplies a gap in the scientific literature by addressing psychobiologic factors as they relate to exercise and sport. It stimulates greater interest in the integration of topics in the growing area known as the psychobiology of physical activities. The content defines and expands the field by covering various disciplines: including psychophysiology, psychoneuroendocrinology, psychoimmunology, neuroscience, physiological psychology, and behavioral genetics (Cacioppo & Tassinary, 1990; Ader et al., 1995; Konttinen et al., 1998; Cacioppo et al., 2000; Ekkekakis et al., 2004).

The concept of flow has been used in psychology to describe the intrinsically rewarding experience that people can experience during an activity. According to Csikszentmihalyi & Csikszentmihalyi (1988), the concept of flow, or optimal experience, is obtained “when all the contents of consciousness are in harmony with each other, and with the goals that define the person’s self. These are the subjective conditions we call pleasure, happiness, satisfaction, enjoyment”.

Theory of flow experience has been applied in various research domains, such as work (e.g. Csikszentmihalyi & LeFevre, 1989), leisure (e.g. Kleiber et al., 1986), learning environments (e.g. Stein et al., 1995), psychopathology (Cikszentmihalyi, 1982), sports (e.g. Jackson, 1992, 1996; Jackson et al., 1998, 2001), and exercise activities (e.g. Vlachopoulos et al., 2000; Jackson & Eklund, 2002). Flow experience has been described as an optimal subjective mental state marked by positive affect, centering of attention, absorption, spontaneous action, total immersion in performing an activity, perception of control over actions and the environment, immediate and unambiguous feedback, loss of self-consciousness, distortion of time, and perception of superior functioning (Cikszentmihalyi, 1982; Cikszemmihalyi & Cikszentmihalyi, 1988; Jackson, 1992, 1996).

The experience of Flow is still one of the least understood phenomena in sport. And yet it is one of the richest, most memorable experiences an athlete will ever know. Some call it a natural "high." Others refer to it as being "in a zone." Whatever it’s called, flow is an elusive and very sought-after psychological state that athletes, coaches, and sport psychologists have tried to understand, harness, and employ to their benefit since Mihaly Csikszentmihalyi first coined the term back in the early 1970s (Jackson & Csikszentmihalyi, 1999). According to Csikszentmihalyi (1997), any activity, mental or physical, can produce Flow as long as it is a challenging task that demands intense concentration and commitment, contains clear goals, provides immediate feedback, and is perfectly matched to the person’s skill level.

It is proposed that a necessary prerequisite to the experience of Flow is a state of transient hypofrontality that enables the temporary suppression of the analytical and meta-conscious capacities of the explicit system (Dietrich, 2004). The transient hypofrontality hypothesis (Dietrich 2003, 2006) offers a new approach to the neurocognitive mechanisms underlying the experience of Flow. The hypothesis is based upon the idea that the brain has the same amounts of resources (approximately 750 ml/min) regardless of the level mental or physical activity. Due to this limited resources the brain gets (15% of total cardiac output per beat at rest; ca. 4% of cardiac output per beat at maximal intensity), the massive and sustained neural activation during aerobic exercise results in the temporary inhibition of brain structures currently unessential to the activity, namely the higher cognitive centers of the prefrontal cortex. However, this reduction is precisely offset by the overall increase in total cardiac output (the heart beats ca. 4 times faster), resulting in a steady perfusion rate.

The brain codes intensity by the rate of neuronal firing. An increased rate of firing increases a neuron’s metabolic needs. Thus, low-intensity exercise is less likely to force the brain to shift its limited resources away from the PFC. Conversely; exercise of high intensity introduces a second limiting factor, as intense exercise cannot be maintained long enough by the cardiovascular system to tax the brain’s resources.

However, a moderate workload would be associated with a considerable increase in neuronal firing rates in a majority of brain tissue that can also be sustained for a long period of time. Thus, exercise intensity at the anaerobic threshold, is the effort most conducive to force a reallocation of resources at the expense of higher cognitive and emotional structures such as prefrontal areas. This fits well with clinical data showing that exercise in the moderate, aerobic range is most beneficial to mental health, a fact that has yet to be adequately addressed by neurochemical theories.

Jackson (1995) presented the factors which may influence the occurrence of Flow in elite athletes. There are many salient factors influencing whether or not Flow occurred included: preparation, physical and mental; confidence; focus; how the performance felt and progressed; and optimal motivation and arousal level. The majority of the athletes interviewed perceived the flow state to be controllable.

Athletes' subjective states and experience generally are neglected by sport psychology research due to an emphasis on performance and competitive outcomes (Kimiecik & Stein, 1992). Jackson et al. (2001) found positive relationships between Flow and aspects of self-concept, and the relationships between Flow and psychological skills use were also in the expected directions. In addition, the predicted positive relationship between a post-event Flow assessment and performance criteria was obtained.

Newburg et al. 2002 represented a concept underlying excellence called resonance. It is captured in the Resonance Performance Model (RPM); the RPM in relation to other performance-related concepts such as Flow was significantly measured.

In order to gain greater insight into the nature of Flow in sport, Jackson (1992) investigated sixteen former US National Champion Figure Skaters. They placed very high value on row-like states, and their descriptions of what was occurring during optimal skating experiences paralleled many of the characteristics of Flow described by Csikszentmibalyi (1975, 1990).

The present study investigates the Flow-Experience and its dynamics under laboratory conditions into three different test conditions (Classification-Number-Test, Stimulus-Response-Test and Without-Additional-Tasks). The velocity of running at the OwnZone®-Area "hard" came ready for use, as previous Flow studies mentioned that the test persons which intentionally “hard” run in their OwnZone® showed significantly higher Flow values than that one of the other two groups (under and over their OwnZone®), independent, whether they subjectively are aware of an optimal Demand-Ability-Fit or not (Reinhardt & Stoll, 2007).

Fundamentals, Research Stand and Hypotheses

2.1 Introduction of Psycopedagogy within Physical Education

Psychopedagogy is a combination of two main branches of study, Pedagogy and Psychology. In specific manner, Psychopedagogy is here as the interaction examination from social, cognitive, and physical climate and educational factors of test. In Psychopedagogy, it is special to the question: in what context is this kind of thinking and acting with learning and teaching? This field presents the principles and procedures, which can help athletes to improve their learning processes (Cagigal, 1962; Ruíz, 1987; Riera, 1989; Capdevila, 1990; Gordillo & Ormo, 1990).

2.1.1 Introduction of Psychobiology within Sport and Exercise

Psychobiology is defined here as the integrative study of behavior from the social, cognitive, and biological levels of analysis. This is a broad scientific Held that encompasses psychophysiology, psychoneuroendocrinology, psychoneuroimmunology, physiological psychology, behavioral genetics, and several areas of neuroscience. The struggle for integration between mind-focused and body-focused approaches within all branches of psychology has been long and arduous.

In contrast to these earlier views, however, contemporary assessments seem to reflect the substantial progress that has taken place in the interim. Taking stock of the achievements of modern psychophysiology, for example, Cacioppo et al. (2000) noted that, although "there are undoubtedly psychological, social, and cultural phenomena whose secrets are not yet amenable to physiological analyses", "psychophysiological research has provided insights into almost every facet of human nature.

Kosslyn et al. (2001) and Uchino et al. (1996) examined the evidence linking social support to physiological processes and characterize the potential mechanisms responsible for these covariations. In addition, they viewed the potential mechanisms coordinating individual differences in cardiovascular reactivity and endocrine and immune responses to acute psychological stress and tried to bridge Psychology and Biology together.

Arguably, progress also has been made in the integrative psychobiological study of human functioning within the contexts of exercise and sport. In the first comprehensive proposal for a psychophysiological orientation in sport psychology, Hatfield and Landers (1983) noted that “very few problem areas within sport and motor behavior have seen psychophysiological approaches systematically applied”. More than a decade later, Dishman (1994) likewise noted that “there has been very little use of biological psychology traditions and methods in exercise science”.

Overall, and despite the progress that has been made in the last 35 years or so, the study of physical activity from a psychobiological perspective, relative to research from other perspectives, has had a limited Impact on exercise science. Psychobiological studies make up only a small fraction of the articles published in exercise science journals.

This disposition is puzzling, especially when the object of scientific study is physical activity. Exercise and sport inherently involve the body and mainly center around the physical nature of the body. Therefore, it is clear to us that an adequate understanding of physical activity cannot emerge if we limit the scope of the investigation to cognitive and social factors and dismiss the role of the body and the brain. We hold this position to be self-evident.

Training in psychobiological theories and procedures is provided in only a very small number of graduate programs in the exercise sciences (Sachs et al., 2000).

Likewise, psychobiology has been only a small area within the sub disciplines of sport and exercise psychology, typically given little space in journals and, at times, treated as a "fringe" area in conference programs. Sport and exercise psychology grew as scientific fields primarily under the dominant influence of the social-cognitive “revolution” in general psychology (Gardner, 1987; Johnson & Erneling, 1997). Still today, these areas of research continue to be influenced heavily by the social constructionist metatheory (Gergen, 1985) and associated self-report and qualitative methods of data collection.

In two studies of Vassend & Knardahl (2005[a,b]) to investigate the relation between neuroticism or extraversion on blood flow or other cardiovascular responses, blood pressure, heart rate, and changes in facial and finger blood flow were monitored in 58 women during three laboratory tasks, i.e. reading out a neutral text, a personally relevant speech (including a silent preparation phase), and a tracking task. Participants rated the tasks as mild to moderate with regard to affect intensity. Arterial pressure, heart rate, and facial blood flow increased during task performance in all three conditions. There were no moderator effects. In other research, the finding implies that the differential magnitudes of vascular responses to mental stress differ among visceral organs (Halliwill et al., 1997; Middlekauff et al., 1997; Hayashi et al., 2006).

Another side for observing the interaction between the neuroscience or psychology and biology is to measure for example the improving of brain function during physical activities, as Kramer & Erickson (2007) suggest that physical activity enhances cognitive and brain function. Gondoh et al. (2009) imply that aerobic exercise training may improve the psychological well-being. Kramer et al. (2006) conclude with a summary and brief discussion of important future directions of research on fitness cognition and brain.

Winter et al. (2007) found that vocabulary learning was 20 percent faster after intense physical exercise as compared to the other two conditions. Stein et al. (2007) mentioned that there is growing basic-science interest in the mechanisms underpinning the positive effects of exercise on brain function and cognitive-affective performance. The study of Ferris et al. (2007) showed that the cognitive function scores improved after all exercise conditions, but they did not correlate with Brain-derived neurotrophic factor (BDNF) changes. The intensity-dependent findings may aid in designing exercise prescriptions for maintaining or improving neurological health. It is concluded that psychogenic factors representing the cognitive, affective, and perceptual domains can significantly influence resting as well as exercise metabolism (Morgan, 1985).

2.2 Memory and Physical Exercise

In literature, studies report a strong correlation between increase on the aerobic capacity and improvement on the cognitive functions (Molloy et al., 1988[a]; Williams & Lord, 1997). However, some controversy remains, once other studies did not obtain similar results (Molloy et al., 1988[b]; Swoap et al., 1994). These conflicting data generate doubts on the actual effects of physical exercises on the cognitive function.

Exercise is beneficial to mood and cognition (e.g. Scully et al., 1998; Colcombe & Kramer, 2003; Tomporowski, 2003). Extensive evidence shows that in the moderate, aerobic range, exercise reduces stress, decreases anxiety, and alleviates depression (Salmon, 2001). Despite the controversies, epidemiological studies corroborate that individual's moderately active present lower risk of developing mental disorders than sedentary individuals, demonstrating that the participation in physical exercise programs brings benefits also for the cognitive functions (Molloy et al., 1988[a]; Mazzeo et al., 1998).

According to McAuley & Rudolph (1995), exercises contribute for the cerebral-vascular integrity, the increase on the oxygen transport to the brain, the synthesis and degradation of neurotransmitters as well as for the decrease on the blood pressure, cholesterol and triglyceride levels, inhibition of the platelets aggregation, increase on the functional capacity and hence the improvement on the life quality. Dietrich (2003) indicated that the hallmark of altered states of consciousness is the subtle modification of behavioral and cognitive functions that are typically ascribed to the prefrontal cortex.

Building on the fundamental principle that processing in the brain is competitive and the fact that the brain has finite metabolic resources, the transient hypofrontality hypothesis suggests that during exercise the extensive neural activation required to run motor patterns, assimilate sensory inputs, and coordinate autonomic regulation results in a concomitant transient decrease of neural activity in brain structures, such as the prefrontal cortex, that are not pertinent to performing the exercise. An exercise-induced state of frontal hypofunction can provide a coherent account of the influences of exercise on emotion and cognition (Dietrich, 2006).

2.3 Characteristics of Implicit and Explicit Memory

Implicit and explicit memories are descriptive concepts thin originally referred to different forms of memory as well as to the memory tests that were used to measure them (Graf & Schaeter, 1985). The type of memory tapped by priming tests was referred to as implicit memory. Whereas the type of memory tapped by recall and recognition tests was referred to as explicit memory. Graf & Schacter (1985) cited three lines of evidence supporting a distinction between implicit and explicit memory. First, healthy adults performed differently on priming and recall/recognition tests in response to a variety of different experimental manipulations: Manipulations that affected their performance on recall/recognition tasks typically did not affect their performance on priming tasks. These performance differences are characterized as functional dissociations. Second, performance on recall/recognition tasks was stochastically independent of performance on priming tasks. Third, the memory performance of densely amnesic patients was impaired on recall/recognition tasks hut not on priming tasks. Although the terms implicit and explicit were not originally intended to refer to hypothetical memory systems, such as procedural and declarative memory (Squire, 1987) or semantic and episodic memory (Tulving, 1983), many researchers currently use these terms to refer to different underlying memory systems (e.g. Willingham, 1994), a practice that has engendered increasing concern (e.g. Schacter & Tulving, 1994). Moreover, the same evidence that Graf & Schacter (1985) originally cited as support for distinguishing between implicit and explicit forms of memory and the tests that measure them has also been cited as support for distinguishing between different memory systems. As forms of memory, however, implicit and explicit memory are equally amenable to explanation by various processing accounts that are based on a single memory system. Generally speaking, what most laymen think of as everyday memory is what theorists have described as explicit memory. In contrast, the category of implicit memory is relatively new. It is commonly assumed that explicit memories are dated by the time and place that an event occurred, implicit memories are not. Thus, a woman may look familiar to an individual, but he may be unable to specify when or where he previously encountered her, which is the hallmark of explicit memory. Theorists frequently associate the term remember with explicit memories and the term know with implicit memories (Gardiner & Java, 1993). The difference pertains to the rememberer’s self-awareness of the time and/or place of a particular past happening versus the individual's general world knowledge. The features that have been used to distinguish implicit memory from explicit memory are summarized. These features include many of those that were originally proposed by Mandler (1985) to distinguish between automatic and nonautomatic memories and by Tulving (1983) to distinguish between semantic and episodic memory. Implicit memory is seen memory development are considered in more detail below. In these tasks, participants are shown an initial study list and are asked to report the first word that comes to mind during the ensuing memory test. Implicit tasks are described as repetition; priming tasks (or. simply, as priming tasks) because the initial presentation of an item presumably primes or increases its accessibility, thereby facilitating the accuracy and rapidity of responding when the item is presented again during the test. (In all instances, an explicit version of these tasks can be constructed by showing participants the same study list hut asking them to recognize or recall a specific item that had appeared on the original list.) Although verbal materials were originally used in explicit; and implicit tasks, pictorial materials have been used more recently in sonic studies (e.g. Musen & Treisman, 1990; Schacter et al., 1990; Schacter et al., 1991; Schacter & Cooper; 1993), particularly in memory studies with young children.

2.4 Explicit and Implicit Systems

In addition to the type of knowledge (emotional or cognitive), the weight of the evidence suggests that the brain also operates two distinct information processing systems to acquire, memorize, and represent knowledge. The explicit system is rule-based, its content can be expressed by verbal communication, and it is tied to conscious awareness. In contrast, the implicit system is skill or experience-based, its content is not verbalizable and can only be conveyed through task performance, and it is inaccessible to conscious awareness (Schacter & Bruckner, 1998; Dienes & Perner, 1999; Ashby & Casale, 2002). Similar distinctions such as conscious-unconscious, declarative-non declarative, voluntary-automatic, or deliberate-spontaneous have been made in other domains.

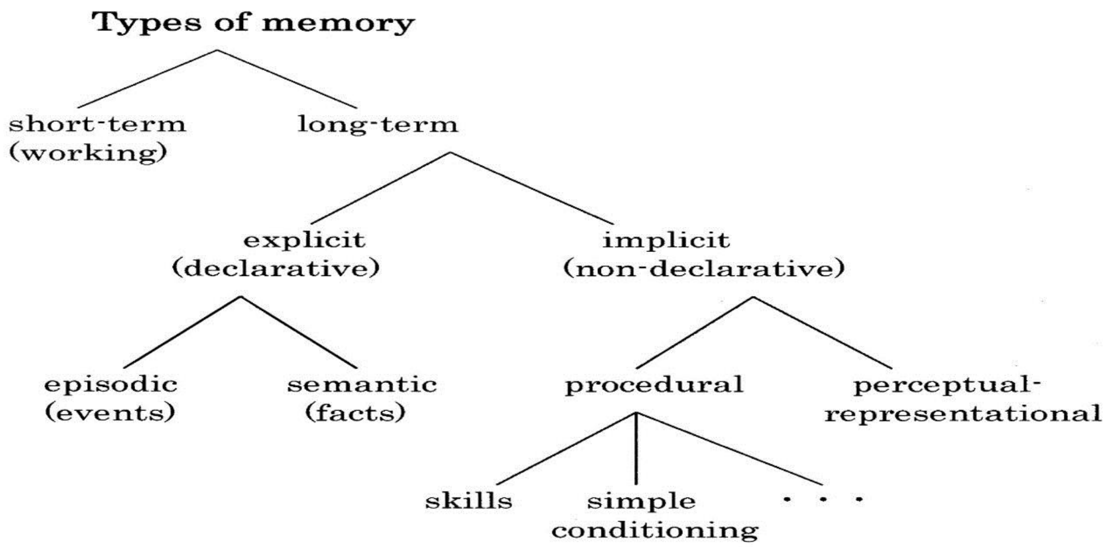

Fig. 1: Types of memory, divided into short-term (working) and long-term (Miyashita, 2004).

Although probably uncommon, information can be acquired exclusively by either system. Implicit learning ‘‘takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired’’ (Reber, 1993). A prototypical example is language acquisition in children, but implicit learning can readily be demonstrated in adults (e.g. Schacter & Bruckner, 1998). For instance, the Tower of Hanoi is a game in which three rings that are stacked according to size on a pole have to be moved, one by one, over an intermediate pole to a third pole without ever putting a larger ring on top of a smaller one. The optimal solution involves seven steps and students learn it readily. Yet, it is virtually impossible for those students to give an accurate account of how they did it. If their verbal account is translated into a computer program the machine is unable to repeat it (Gazzaniga et al., 1998). In contrast, explicit learning is not “learning-by-doing” but proceeds through the conscious application of rules. In the process, the explicit system forms a mental representation that includes not only the actual information, but also knowledge about what and the fact that it was acquired. A prototypical example might be the acquisition of a second language in adulthood.

A more common scenario, however, is that learning engages both systems simultaneously? Studies on neurological patient populations and health subjects suggest that a typical learning situation results in the formation of two distinct mental representations, one explicit and one implicit (e.g. Milner et al., 1968; Schacter, 1987).

Because each system sub serves different functions, it is unlikely that either representation alone is a complete characterization of the learned task. While some information may be represented in both systems, other information may reside in one system but not the other. For instance, cooking a multi-course dinner requires a variety of tasks that are exclusively explicit, such as mixing ingredients according to instruction, while a variety of other tasks, such as deciding when the vegetables are done, are largely implicit.

The degree to which either system has a complete representation depends on the amount of practice and the nature of the task. Consider, for instance, language. A person's native language is entirely learned and largely represented in the implicit system, but with considerable study the explicit system can develop its own representation of the phonology, semantics, and grammar. This is not easy, as any English major will tell you, and a paramount requirement to be able teach a native language to others. On the other hand, a second language that is learned in adulthood is acquired painstakingly by the explicit system with no "fee" or intuitive understanding for it. Yet, with extensive practice, often nothing short of total immersion into the respective linguistic environment, the knowledge can also become represented in the implicit system. Building a representation in the implicit system is referred to as "internalizing" or becoming ''second nature'' in colloquial speech. Either case would result in two complete and independent representations, which is almost certainly a defining characteristic that qualifies a person as a true expert. Thus, knowledge can be explicit and/or implicit, but is mostly represented in varying, partially overlapping degrees of each.

2.4.1 Explicit Tasks

The explicit tasks most commonly used are recall and recognition tasks, in a recall task, subjects are exposed to a series of stimuli (acquisition phase). Sometime later, they are asked to recall as many of the stimuli as possible with (cued recall) or without (free recall) the help of a list of cues. Recall tasks typically are used to probe verbal memory. In that case, the stimuli would be a list of words, and the cues could be, for example, the first two letters of each. Strict recall tasks would be quite difficult to use with faces and odors as they would require that subjects recreate the stimuli (i.e. draw previously faces or recompose odors). Such tasks would be possible only for paint perfumers. However, it is worth mentioning that such procedures have used by Tuorila et al. (1996) and by Vanne et al. (1998) for testing quantitative memory for taste. Those authors mentioning that sonic authors have used a “recall” task with odors and faces, but in fact have asked their subjects either to provide a verbal description of the stimulus or to recall not the stimulus itself but the name of the stimulus. That last task, however is possible only with familiar stimuli for which subjects already have names. That paradigm has been used, for example, by Hanley et al. (1990) with photographs and by Annett & Lorimer (1995) for familiar odors of common household substances. For faces, subjects were first presented with a series of famous faces and then asked to write down the names of as many faces as they could remember. For odors, authors asked their subjects to write down the names, or brief descriptions, of as many of the previously smelled odors as they could remember. Then participants were presented with each odor again and asked to provide a verbal label or a brief description for it. Because of the idiosyncratic nature of odor labeling, that procedure was chosen to facilitate the scoring of recall responses. It is clear that such recall tasks with odors and ¿aces are not equivalent to the recall task with words, because subjects are not asked to recall the stimuli, but to give the names the stimuli.

The recognition task is the experimental paradigm most frequently used to study explicit memory for odors and faces. The acquisition phase is identical with that of a recall task, but the testing phase differs in that subjects have to recognize the target stimuli among distracter stimuli. This is usually done in one of two different ways: a two-alternative forced choice (2AFC) or a yes/no task. In a 2AFC task, stimuli are presented by pairs composed of an “old” stimulus (presented during the learning stage) and a “new” one. Subjects are asked to determine which stimulus in a pair is the old one. In a yes/no task, old or new stimuli arc presented one at a time, and subjects are asked to answer “yes” or “no" to the question “Were you presented with this stimulus in the first part of the experiment?”

2.4.2 Implicit Tasks

Implicit memory tests were first designed to study implicit memory for words. The general principle of these tests is as follows: First subjects are presented with a list of words. Then they are asked to perform a task such as word-stem completion, word-fragment completion, tachistoscopic identification, or anagram resolution. Half of the words presented during this task will have been in the list presented in the first part of the experiment (targets); the other half will be distracters. Implicit memory is demonstrated if the performance on the second task is greater for targets than for distracters. That type of test has been extended to the study of visual memory using picture-completion or picture-clarification tasks. The general idea of “completion”.

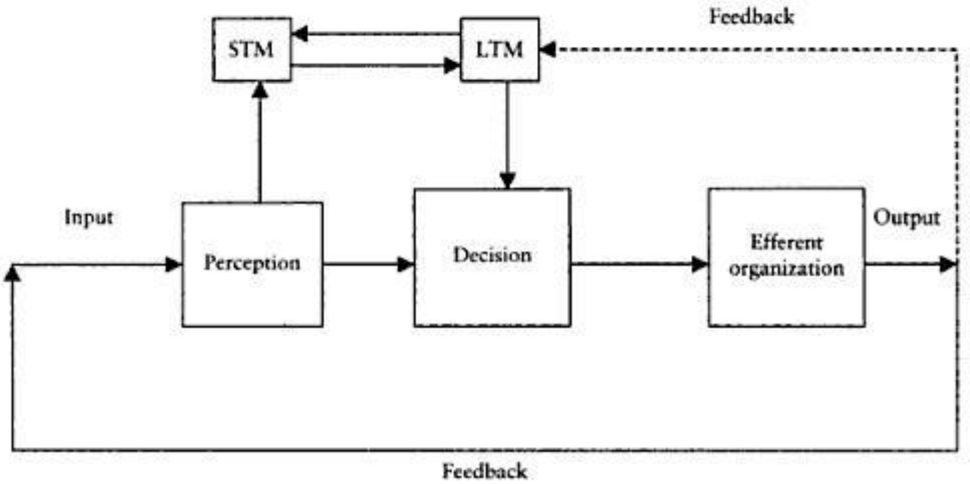

Fig. 2: Model of information processing (adapted from Welford. 1968): reproduced by permission of Thomson Publishing Services from Welford, A.T. 1968 Fundamentals of Skill, Methuen. London, UK

However, is rather difficult to apply to odors and faces. Thus slightly different paradigms are generally used for those stimuli. They rely on the assumption that the presentation of a first stimulus sharing some properties (visual, olfactory, or semantic) with a second stimulus should affect the processing of the second stimulus more than would the presentation of an irrelevant stimulus.

Bruce & Valentine (1985) were the first to use that type of paradigm to study implicit memory for faces. They presented subjects with a series of famous-face pictures or names. The subjects’ task was to identify the faces from their pictures or to read their names. After a 20-minute break they were asked to identify or recognize a second series of face images. That second series was composed of faces whose pictures had been presented in the first series, faces whose names had been presented in the first series, and new faces (control).

Implicit memory was demonstrated when performance was better for faces from the first list than for new faces. Since that first work, numerous variations of that procedure have been used, but the general principle remains the same (Bruyer, 1990). All such variations have converged to the finding that face identification is facilitated by previous presentation of either the faces themselves or their names, whereas face recognition (i.e. familiarity judgment) is facilitated only by previous presentation of the faces, not by previous presentation of their names.

In comparison, as discussed by Mair et al. (1995), implicit memory for odors has received scant attention in the literature. Schab & Crowder (1995) were the first to report experiments testing implicit memory for odors.

Their paradigm was similar to that used with faces. During the learning phase, subjects were exposed to a series of jars filled either with an odorant or with water. As each jar was presented, they were given the name of the odor they were actually (odor-and-name condition) or supposedly (name-only condition) smelling. During the testing phase, subjects were presented with a second series of jars containing an odorant. That series included the odorants presented during the learning phase in the odor-and-name condition and in the name-only condition, as well as new odorants. Their task was to identify or detect the odors, or judge their pleasantness. As before, implicit memory was demonstrated if performance was better for odors presented in the first series than for new odors. The data showed that, as was the case for faces, a name priming effect was observed in the identification task (i.e. a significant difference between the name-only condition and the control condition was observed) but not in the detection task. Because that effect was even larger in the name-plus-odor condition, the authors concluded that there was odor priming.

However, it is important to note that the paradigm used by Schab and Crowder differed on one point from that used by Bruce & Valentine (1985). In Schab and Crowder's experiments, odors were always presented with their names in the learning stage, but Bruce and Valentine's experiment included a learning condition in which faces were presented alone. As pointed out by Degel & Köster (1998), it is not clear that, given such conditions, a "pure" implicit memory for odors was tested. In fact, Schab & Crowder's experiments would allow to study the impact of verbal mediation in odor identification. As indicated by the authors themselves, the superior performances in identification scores and reaction times for the odor-and-name learning condition compared with the name-only learning condition may have been caused by a strengthening of the association between a perceptual representation and its related verbal label or by an increased availability of a verbal label because of prior activation of the perceptual representation in combination with its verbal label. That could explain why a priming effect was observed only in their first experiment, when the test task was an identification task. Nevertheless, because our identification Capacity for odors is not crucial in day-to-day life, the identification task should be replaced by another task based on discrimination. In particular, it would seem possible to adapt the paradigm used for faces to odors by presenting an odors-only condition during the learning stage, and not an odors-and-labels condition.

In an attempt to minimize the effect of verbal processing, Olsson and Cain (1995) used a subvocal identification paradigm to demonstrate odor priming. Subjects were asked to indicate when they had last smelled six monorhinally presented odors. After a 10-minute break, they were presented with the same odors as well as six newodors. Their taskwas to press a button when they realized what they were smelling, without giving a verbal label. A positive priming effect (i.e. primed odors were identified faster than control ones) was observed when odors were presented to the left nostril. However, as pointed out later by Olsson (1999), even though subvocal identification was used, the testing task was a verbal task, and consequently that was not “a process-pure test of priming.”

In a later paper, Olsson (1999) reported another repetition priming experiment based on latency of identity rejection. A positive priming effect was observed for odors that could not be identified. On the contrary, a negative priming effect was observed for odors that could be identified. Thus, it seems that identification may interfere with the encoding or retrieval of odor memory. However, the task used during the learning stage (i.e. to judge when they had last smelled the odor), because of its emphasis on remembering, almost certainly would have precluded true measures of implicit memory in the final phase.

Recently, Degel & Köster (1999) reported a new method to analyse implicit memory for odors. During the learning stage, subjects completed a creativity test, a letter-counting concentration test, and a mathematical test in several weakly odorized rooms without being aware of the odors. In that experiment the Testing Odor Memory presentation of the stimuli during the learning stage was somewhat similar to a tachistoscopic word presentation in that subjects were not aware of the stimuli.

After a 30-minute retention time, subjects were shown photographic slides of different surroundings, including the room they had been in, and were asked to rate how well each of 12 odors, including the one they had been exposed to, fitted with each context shown in the pictures. The hypothesis was that if there was an effect of implicit memory for odors, the ratings of fit between odors and contexts would be positively influenced by odors previously experienced unconsciously and subliminally in the test rooms. The data showed that subjects who had worked in a room with a given odor subsequently assigned a higher fit for that odor to the picture of that room than did subjects who had worked in rooms with other odors, but that was true only for people who could not identify the odor by its name.

2.5 Storage of Memories

It is tempting to think of memories of past behaviour as being immediately retrievable on demand as a complete record of past events. Unfortunately, memory does not appear to work this way, in most cases. Therefore, it is important to consider what type of physical activity information may be stored in memory and how these items are organized because this information forms the basic substrate from which individuals provide physical activity self-reports. A significant issue to consider when evaluating self-reports of physical activity, particularly as our instruments have shifted from the assessment of a single domain of physical activity (i.e. leisure) to the assessment of the full range of activities encountered in daily life (e.g. household chores, occupational activity), is how information about physical activity behaviour gets stored in memory. Obviously, if physical activity events are never stored in memory, there is no chance that a specific episode of activity can be recalled with any accuracy. It should also be noted that a lack of storage of information about specific activity events does not mean that respondents will fail to report these activities when they are asked to do so on a survey. Remarkably, this may be acceptable in certain situations. The cognitive model of Baranowski & Domel (1994) has been adapted here to illustrate the basic cognitive processes thought to be involved in the storage of autobiographical memories. This model, by carefully describing the individual processes involved in the storage of memories, provides a useful tool for identifying potential weaknesses in the storage process that are germane to the assessment of physical activity. The basic cognitive structures in the model are the sensory register, short-term memory, and long-term memory. The sensory register works to screen the hundreds of bits of possible information present at any moment in our immediate environment (e.g. sights and sounds), and it can focus attention on specific sensory items in the environment or on our personal behaviours. For information about physical activity to be perceived by the sensory register, attention must be given to the behaviour. Information that is attended to is perceived (or comprehended) and enters short-term memory where it is evaluated by the experience monitor. Short-term memory is where conscious intellectual activity occurs and, perhaps, up to five items can be held here at any one time (Baranowski & Domel, 1994).

Certain information is transferred from short-to long-term memory for storage. The process of labelling and storing items in long-term memory is called encoding (Sudman et al., 1996). Autobiographical information appears to be encoded in long-term memory in a hierarchical manner with specific individual events being embedded within meaningful clusters of information sequences. These sequences often appear lobe chronologically arranged (Sudman et al., 1996). That is, individual episodes of physical activity-unless they are extremely meaningful to the individual-may not be stored as individual items in long-term memory. Thus, it is unlikely that they will become available for recall at some point in the future. If this is the case, how are we able to pro-vide useful information about experiences that we may not be able to recall directly? Autobiographical information is thought to be stored as two conceptually distinct types of memory: episodic and generic. Episodic memories are specific recollections of individual and innumerable autobiographical events. This type of memory is generally employed in a recall task when one seeks to enumerate individual episodes of less-frequent occurrences, or a small number of events that occur in a short time frame (e.g. the number of days of exercise last week). Episodic memories are thought to contain contextual information about the actual events that occurred (e.g. locations, people, and actions) but may not contain specific information about absolute time (Brewer, 1994). Reconstruction of time from episodic memories, and for our purpose physical activity duration, appears to be 'derived from the contextual information that is available on recall. In other words, in response to a question about the number of minutes spent walking yester-day morning, a value for the specific duration of walking in this period is unlikely to reside in memory, but an estimate of duration could re-constructed using the contextual information that is available. In contrast to episodic memories, generic memories are recollections of the general events or pat-terns of events (or activities) that occur in one's life. This form of memory is employed to provide self-reports of physical activity when specific and innumerable memories are not stored. For example, one may be able to provide a generic report of the frequency of playing golf last summer (once or twice a week) but would be unable to recall and enumerate each individual outing. In general, more frequent and familiar events in one's life appear to be stored as generic memories rather than as discrete memories of the individual events that makeup the generic whole (Brewer, 1994). With the exception of self-reported physical activity methods that require a short recall period (e.g. the last 24 hours), or specific behaviours that occur over a short period of time (e.g. exercise bouts in last 7 days), most self-reported physical activity instruments rely on information derived from generic mummy. This cognitive aspect of physical activity reporting may be one of the factors contributing to the generally lower reproducibility coefficients for light- to moderate-intensity physical activities on various physical activity assessments that seek to quantify these common and frequently encountered behaviours (DiPietro et al., 1993; Jacobs et al., 1993; SaIlis, 1997). For example, evaluation of the 14-day repeatability data front the exemplary and detailed validation work or the Yale Physical Activity Survey (YPAS) of DiPietro et al. (1993) suggests that more prevalent household activities, which are likely to be reported using generic memory, generally have lower reliability coefficients compared to more specific exercise activities that may be reported using episodic memory (see figure 3). Given that the YPAS time frame for respondents to report is stated as a "usual week in the last month," the 14- day recall interval from which these analyses were derived should largely reflect variation in reporting the same physical activity behaviours rather than variation in the underlying behaviours themselves. Careful consideration of the type of memory used in self-reports of physical activity on surveys or in interviews is likely to suggest ways to mom effectively merge our assessment strategies with the cognitive processes employed and, in the process, facilitate better reporting of the behavioural characteristics of the physical activity on these instruments. Consideration of these cognitive factors will also provide investigators with an additional framework front which to interpret the information provided by two the respondent. Now that we've outlined some of the basic aspects of memory storage, and the sub-strate from which self-reports of physical activity am based, let us examine the process of retrieving information from memory in response to a question.

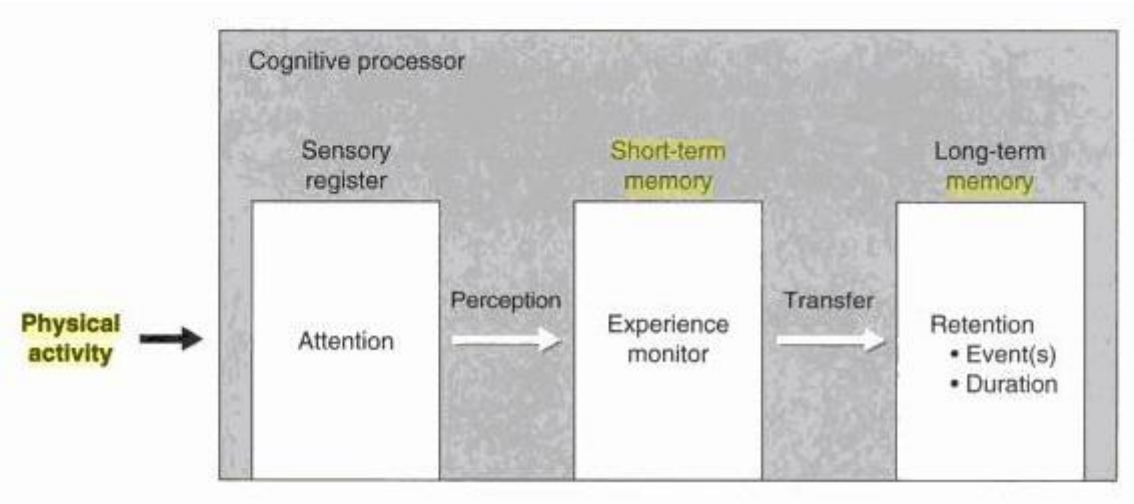

Fig. 3: Cognitive structures and memory storage. Adapted from Baranowski and Domel, 1994

The nature of the task appears to determine the initial degree of explicitness and implicitness. From an evolutionary perspective, the existence of two distinct systems for knowledge representation indicates that each must be specialized in some way. Thus, each system is likely to be predisposed to handle certain tasks or certain task features. For instance, tasks that are either one-dimensional, i.e. can be described by a single rule, or task that have relatively few conjunctive (sequential) rules are easily learned by the explicit system. An example is the Wisconsin Card Sorting Task (WCST), in which cards are sorted by one of three characteristics: color, number, or shape. The person is asked to discover the sorting rule empirically using only feedback from the examiner. When the sorting rule is changed, the person is to adapt to the new rule. Subjects have no problem accurately describing the rule(s) verbally. However, as the task complexity increases and the optimal rule is either multi-dimensional, i.e. requires the integration of several rules, or is probabilistic in nature, the task is notoriously difficult to describe explicitly. This is nicely illustrated in a categorization experiment by Waldron & Ashby (2001). The experimenters created 16 stimulus cards that could vary in four dimensions: background color (blue or yellow), embedded symbol color (green or red), symbol number (1 or 2), and symbol shape (square or circle). The two levels of each dimension were coded in a binary fashion as either +1 or 0. In addition, one dimension was arbitrarily selected to be irrelevant. The subject was presented with a stimulus consisting of a combination of eight of these cards and was asked to decide empirically whether the stimulus belongs to category A or B. The implicit rule that determined category membership was: ‘‘The stimulus belongs to category A if the sum of the values on the relevant dimensions >1.5; otherwise it belongs to category B.’’ The interesting result of the study was that virtually all subjects achieved perfect performance, however, no one was able to describe the rule. An analogous real-world illustration might be the difficulty of describing the offside rule in soccer in a single sentence. Thus, tasks that have less salient rules are more readily imprinted in the implicit system.

This raises the question, given that one-dimensional tasks, such as the WCST, are also coded implicitly, why the explicit system exists at all. This is, of course, part of the larger question of the evolutionary significance of consciousness. Anticipating a discussion in the next section, a simple solution has been offered by Crick & Koch (1998). A frog responds stereotypically, zombie-like if you will, to visual input, i.e. to small, preylike objects by snapping, and to large, looming objects by jumping.

These responses are controlled by rigid and reflexive, but fast-responding systems. As the number of reflexive systems must grow to handle increased complexity, such an organization becomes inefficient. A more advantageous solution is to evolve a single system capable of temporarily buffering and sustaining multiple representations, so that the organism can examine them before making an output decision. This is particularly useful when two or more of the organism’s systems generate conflicting plans of action. Thus, implicit knowledge can be thought of as task-specific, that is, it is inaccessible to other parts of the system and thus less versatile (Karmiloff-Smith, 1992).

Explicit knowledge on the other hand can dramatically increase behavioral flexibility, because it can be broadcast to a global workspace (Baars, 1989), which allows us to test conflicting hypotheses and to integrate seemingly counter-intuitive notions about the world. For instance, most scientific knowledge is not intuitive and the implicit system would have never learned that the earth is round, that it has a molten core, or that it is at the outer arm of some small galaxy, to say nothing of 11-dimensional string theory.

2.6 The Flow Experience

The autotelic experience, or engaging in an activity for intrinsic rewards, is very similar regardless of its context (Csikszentmihalyi, 1975). Those people who have been studied for the flow experience have described it in very similar ways even though one may be fastening screws on an assembly line, or performing the most complex heart surgery (Csikszentmihalyi, 1991). This experience is so desirable that one wishes to repeat it as often as possible.

To achieve optimal experience, a balance is required between the challenges perceived in a given situation and the skills a person brings to that situation. A challenge includes “any opportunity for action that humans are able to respond to” (Csikszentmihalyi, 1988). Any possibility to which a skill corresponds can produce flow.

Some classic examples of this are winning the friendship of another person, writing poetry, closing a business deal, doing a favorite hobby, or playing a favorite sport, etc. To remain in flow, one must increase the complexity of the activity by developing new skills to meet new challenges. Example: a tennis player just beginning can be in a flow experience just by hitting the ball over the net. The challenge is not that great, but neither are her skills. As she plays more and more, and increases her skills, she will have to take on greater challenges to attain a flow experience again. If the perceived challenge is greater than her skill (ex. her playing Andre Agassi when she can barely keep the ball in play), she will perceive anxiety. If however, her skills are greater than her challenge (ex. playing her little sister after she has already won the state championship), she will perceive boredom. The following diagram (Csikszentmihalyi, 1991) will help illustrate this:

It is this feature that makes flow such a dynamic force in the evolution or growth of consciousness (Csikszentmihalyi, 1988). Because flow is perceived as an optimal experience, a person will want to continue in that state as often as possible. The flow state can become an addiction, and often does. However, it drives the self to higher and higher levels of complexity. It forces people to stretch themselves, take on more and more challenges, and improve their skills and abilities (Csikszentmihalyi, 1988).

The flow experience usually occurs in structured activities such as games, ritual events, sports, artistic performances, etc. (Csikszentmihalyi, 1988). It does not normally occur in everyday life because challenges and skills are rarely balanced. However, even if skills and challenges are balanced, it does not guarantee a flow experience occurring.

This is due to the fact that activities only provide the challenges; it is still up to the individual to recognize the challenge, provide the skills, and extract enjoyment from the activity. Also, the complexity of a flow activity is limited by the degree of challenge it can provide, and by the willingness and "creativity" of the person to create challenges in an activity. A person who can do this well, one who has the ability to enter a flow state relatively easy, is said to have an "autotelic personality" (Csikszentmihalyi, 1988).

2.6.1 Flow - A special case of intrinsic motivation

Some of the most innovative studies of enhancing intrinsic motivation come from the work of Mihaly Csikszentmihalyi (1990). Whereas many researchers have tried to determine which factors undermine intrinsic motivation, Csikszentmihalyi investigated exactly what makes a task intrinsically motivating. He examined rock climbing, dancing, chess, music, and amateur athletics-all activities that people do with great intensity but usually for little or no external reward. In sport, Sue Jackson has led the research in this area, studying flow experiences in at Metes from a variety of sports. Jackson and Csikszentmihalyi have also collaborated on a book, Flow in Sport: The Keys to Optimal Experiences and Performances (Jackson & Csikszentmihalyi, 1999). Through their research, Jackson and Csikszentmihalyi have identified a number of common elements that make sport activities intrinsically interesting. These essential elements of the flow state include the following:

• Balance of challenge and skills. The most important part of Csikszentmihalyi's definition of flow is the balance between one's perceived skill and challenge. An easy win or lopsided loss will rarely get one into flow. As one hockey player noted, “When I have a competitor to push in to my limits and provide a real challenge is when I can get into the zone.” For flow to occur it is imperative that an athlete believe that he or she has the skills to successfully meet the physical, technical, and mental challenges faced.

• Complete absorption in the activity. The participant is so involved in the activity that nothing else seems to matter. A basketball player stales. “The court-that’s all that matters. Sometimes I think of a problem, like fighting with my girlfriend, and I think that's nothing compared to the game. You can think about a problem all day but as soon as you get in the game, the hell with it. When you’re playing basketball, that's all that's on your mind.”

• Clear goals. Goals are so clearly set that the athlete knows exactly what to do. This clarity of intention facilitates concentration and attention. As one swimmer said of the flow experience, I knew exactly how I was going to swim the race.”

• Merging of action and awareness. The athlete is aware of her actions but not of the awareness itself. This mental slate is captured by a volleyball player who states. “The only thing that goes through my mind is performing well. I really don't have to think, though. When I'm playing [volleyball], it just comes to me. It's a good feeling. And when you’re on a roll, you don I think about it at all. If you step back and think why you are so hot all of a sudden you get creamed.”

• Total concentration on the task at hand. Performers report that they feel like a beam of concentrated energy. Crowd noises, opponent reactions, and other distractions simply don't matter. The focus of attention is clearly on the task at hand. A tennis player demonstrates this total focus: “All that mattered was the tennis court and the ball. I was so into the zone and focused that the ball looked like a water-melon.”

• Loss of self-consciousness. Performers report that their ego is completely lost in the activity itself. A rock climber captures this feeling well: “In rock climbing one tends to get immersed in what is going on around him-in the rock, in the moves that are involved search[ing] for handholds, proper position[ing] of the body-so involved he might lose the consciousness of his own identity and melt into the rock:

• A sense of control. This element of flow refers to the fact that the athlete is not actively aware of control; rather, he is simply not worried by the possibility of lack of control. A racquetball player demonstrates this sense of control: “At times when I have super concentration in a [racquetball] game, nothing else exists—nothing except the act of participating and swinging at the ball. The other player must be there to play the game; I’m not concentrated with him. I’m not competing with him at that point. I'm attempting to place the ball in the perfect spot, and it has no bearing on winning mid losing.”

• No goals or rewards external to the activity. The athlete participates purely because of the activity itself, without seeking any other reward. A chess player makes this point by saying, “The most rewarding part of chess is the competition, the satisfaction of pitting your mental prowess against someone else. I’ve won trophies and money, but considering expenses of entry fees, chess association, et cetera, I’m usually on the losing side financially.”

• Transformation of time. Athletes in flow typically report that lime seems to speed up, although for some it slows down. However, most individuals in flow report transformations in their perceptions of time. As one athlete said, it was over before I knew it:

• Effortless movement. This element refers to the fact that the athlete is performing well but yet is not really thinking about it and doesn’t appear to be trying too hard. A figure skater captures this element well: it was just one of those programs that clicked. It's just such a rush, like you feel it could go on and on and on, like you don't want it to stop because it's going so well. It's almost as though you don’t have to think, it’s like everything goes automatically wit how thinking. It’s like you're in automatic pilot, so you don't have any thoughts.”

These elements represent the essential features of optimal performances, which athletes have described as “hot: “in a groove; on a roll, ”or“ in the zone; a special state where everything is going well and you’re hitting on all cylinders. Csikszentmihalyi calls this holistic sensation flow, in which people believe they are totally involved or on automatic pilot. He argued that the flow experience occurs when your skills are equal to your challenge. Intrinsic motivation is at its highest and maximum performance is achieved, however, if the task demands are greater than your capabilities, you become anxious and perform poorly. Conversely, if your skills are greater than the challenges of the task, you become bored and perform less well.

For example, if an athlete has a high skill level and the opponent is also highly skilled (e.g. high challenge), then the athlete may achieve flow. But if an athlete with less ability is matched against a strong opponent (high challenge), it will produce anxiety. Combining low skills and low challenge results in apathy, whereas high skills and low challenge result in boredom. Stavrou et al. (2007) tested the notion of these four quadrants and the achievement of optimal experience. Results revealed that participants in the flow and relaxation conditions exhibited the most optimal affective states and performance, whereas apathy produced the least optimal states (boredom was between apathy and flow). By structuring exercise classes, physical education, and competitive sports to be challenging and creative, you foster better performance, richer experiences, and longer involvement in physical activity.

2.6.2 How People Achieve Flow

If they knew how, coaches and teachers would likely want to help students and athletes achieve this narrow framework of flow. So the logical question is, how does one get into a flow state? Research studying athletes from different sports (Jackson, 1992, 1995) found that the following factors were most important for getting into flow:

• Motivation to perform. Being motivated to perform-and to perform well-is important to getting into flow. When individuals lack such motivation, flow is much more difficult to achieve. The balance between challenge and skill may be the most relevant area to focus on to help ensure that the individual is optimally motivated.

• Achieving optimal arousal level before performing. Being relaxed, controlling anxiety, and enjoying the activity contribute to flow. Jackson found that some individuals clearly preferred to be more relaxed, whereas others canted to be more energized. How-ever, several athletes spoke of finding a balance between calmness and arousal. As one skater said. "Relaxation and confidence—but you have to be on edge; you can't be too relaxed. You have to be concerned about something (Jackson, 1992).

• Maintaining appropriate focus. Keeping a narrow focus, staying in the present, focusing before the performance, and focusing on key points in one's activity are critical to maintaining proper focus. Csikszentmihalyi (1990) referred to concentration on the task at hand as one of the most frequently mentioned dimensions of the flow experience. One skater asserted the positive result of focusing fully on the upcoming performance this way: The fact that you're so focused, you're able to concentrate easily- (Jackson, 1992). In addition, recent research on mindfulness (the nonjudgmental focus of one's anent ion on the experience that occurs in the present moment) has revealed that athletes higher on mindfulness score higher in skills–challenge balance, merging of act ion and awareness, concentration, and loss of self-consciousness than athletes low on mindfulness (Kee & Wang, 2008).

• Precompetitive and competitive plans and preparation. Along with mentioning confidence and positive attitude, athletes mentioned planning most often in describing factors that influence their achieving flow states. Following precompetitive routines, feeling totally ready, having a competitive plan, and anticipating potential unusual events are clearly important components of preparation. For example, a javelin thrower stated, "The fact that I've done everything possible on my mental and physical side makes me feel confident. Every facet is covered. That reassures my conscious mind that I've done everything—then I just have to let myself switch off and let it happen" (Jackson, 1995).

• Optimal physical preparation and readiness. Having done the necessary training and preparation before-ham!, working hard, and feeling that you are physically ready and able to have good practice sessions before competing are all critical to getting into and maintaining a flow state. In addition to attention to rest and training, nutrition also appears important for setting optimal conditions for the flow state to occur. In addition, athletes report that believing they were physically prepared helped boost their confidence and ability to stay in a flow state for a longer period of time.

• Optimal environmental and situational conditions. Although people can set the tone for achieving a flow state by altering their own internal climate, athletes also cited influences of environmental and situational conditions that affected their ability to achieve a flow state. Such conditions as a good atmosphere, positive feedback from the coach, no outside pressures, and optimal playing conditions enhance the probability of flow occurring.

• Confidence and mental attitude. Confidence is a major help to achieving a flow state; conversely, self-doubt and putting pressure on oneself are perceived as factors that can disrupt flow. Believing you can win, thinking positively, blocking negatives, and enjoying what you're doing all help build confidence. But maybe most critical is believing that you can meet the challenge you face. As one athlete stated, I think probably the most important thing, for me is the feeling that I've got the ability to be in that situation (Jackson, 1995).

• Team play and interaction. In team sports, getting into flow sometimes depends on (or at least is influenced by) your teammates. Positive team inter-actions such as good passing, playing as a unit, and open communication are helpful in achieving flow. In addition, trusting your teammates and having a shared sense of purpose are also important for cohesive team interactions.

• Feeling good about performance. The factor for getting into flow that athletes mentioned most often was feeling good about their performance and movements. In essence, receiving feedback from their movements and being in control of their bodies give athletes a sense of ease in moving. Anyone who has participated in sport knows that sometimes things just feel right, smooth, effortless, and in sync. These feelings are usually related to getting into a flow state.

2.6.3 Controllability of Flow States

Can individuals control the thoughts and feelings connected with flow? The athletes interviewed by Jackson (1992, 1995) varied in their responses regarding the controllability of their flow states. Overall, 79% perceived flow to be controllable, whereas 21% believed it was out of their control. Athletes who believed that flow was controllable made comments like these: “Yeah, I think you can increase it. It's not a conscious effort. If you try to do it, it's not going to work. 1 don't think it's something you cart turn on and off like a light switch (Jackson, 1992). A triathlete noted, “I think I can set it up. You can set the scene for it, maybe with all that preparation. It should be something that you can ask of yourself and get into, I think, through your training and through your discipline” (Jackson, 1995). Some athletes, although considering flow to be controllable, placed qualifiers on whether it would actually occur. A javelin thrower captured this perception in his remark, “Yeah, it's controllable, but it's the battle between your conscious and subconscious, and you've got to tell your conscious to shut up and let the subconscious take over, which it will because it's really powerful” (Jackson, 1995). A rugby player believed that flow was not controllable in learn sports: "It all comes back to the team—everybody, all the guys knotted in together and it just rolls along for 5, 10 minutes, half an hour, going very well, but then someone might lose concentration or go off beat or something and then you'd be out of that situation you were just in. and you can't have any control over that" (Jackson, 1995). Jackson's studies suggest that although athletes cannot control flow, they still can increase the probability of it occurring by following the guidelines stated here and focusing on things within their control, such as their mental preparation. Most enlightening is a study by Pates et al. (2001), who examined the effectiveness of hypnosis training on flow states and golf putting performance. The hypnosis training involved deep breathing, progressive relaxation, and a multisensory imagery type of experience focusing on best past performance and associated with a t rigger cue. Findings revealed that the five golfers studied increased both their putting performance and flow scores after using hypnosis, showing that athletes can be trained to increase their flow experiences. In a study of 236 at Metes, Jackson et al. (2001) also found that flow was related not only to performance but to the psychological skills athletes typically use. Particularly, keeping control of one's thoughts and emotions and maintaining an appropriate level of activation and relaxation were psychological skills related to flow.

2.6.4 Flow Experience Concept in Different Directions

The concept of flow was first introduced by Mihaly Csikszentmihalyi in his book Beyond Boredom and Anxiety (1975), while attempting to find out what drove people in free-time activities that did not seem to follow the utility-centered motivational theories of the time.

A person could try to reach flow state by means of a twofold dynamic. For example, in an anxiety state, the person would try to increase personal skills to balance the level of challenge, or, if the person experiences relaxation, he or she would try to seek more challenging sitaations (Moneta & Csikszentmihalyi, 1996). In other words, as a person masters a challenging activity, his or her skill level increases. To continue experiencing flow, the person must try to find more complex skills, and so on, building greater complexity in the person (Cikszentmihalyi, 1990).

From several interviews he derived what appeared to be a form of intense engagement and enjoyment, which he named flow. The phenomenon is easily recognized by most people, experienced equally during sports, work, artistic performance and many other activities.

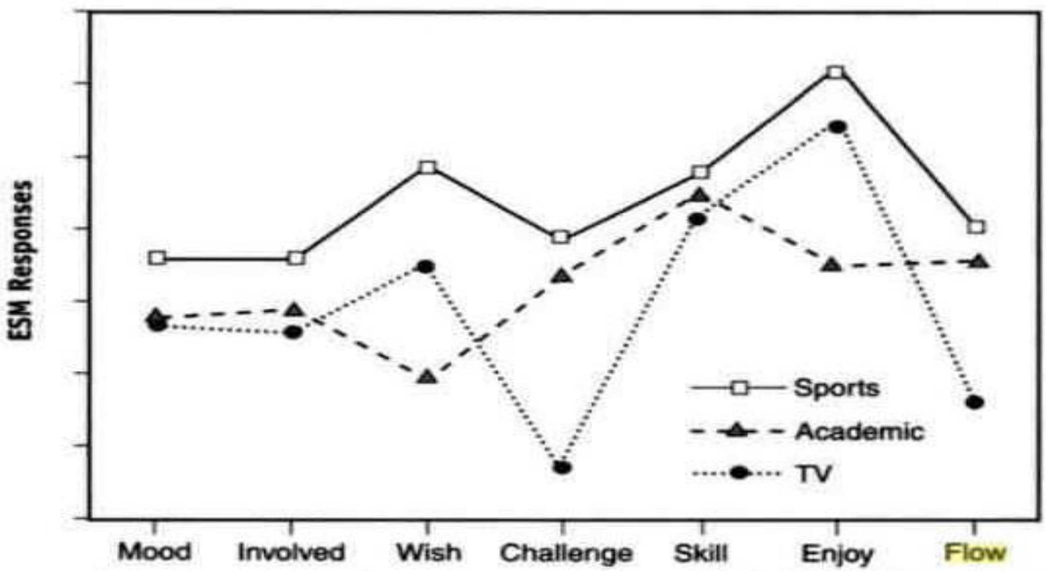

Fig. 4: ESM responses from a sample of more than 800 representative U.S. adolescents aged 11 to 18.

Yet, after three decades of research, the understanding of flow is still fragmented (Novak et al., 1998). The most immediate impact was on those scholars who study the psychological and sociological implications of free time - on the literatures of play, sports, leisure, and recreation (e.g. Widmeyer, 1978; Pearson, 1979; Sutton-Smith, 1979; Iso-Ahola, 1980; Kleiber, 1980, 1981, 1985, 1986; Kleiber & Barnett, 1980; Egger, 1981; Neulinger, 1981[a,b]; Kelly 1982, 1986; Ingham, 1986; Samdahl, 1986).

Cultural anthropology is another field to which the concept of flow turned out to be relevant. Here it was Victor Turner (1974) who saw the similarity between the flow experience and a series of phenomena he had been studying for years, the so-called liminal situations. Following Turner's lead, the flow concept became an influential idea in the anthropology of play (Cheska, 1981; Harris & Park, 1983).

The general conceptualization of flow as an attentional process of absorption in the task at hand, which generates intrinsically rewarding feelings, fosters further understanding of flow experience in physical activity. Furthermore, systematic cross-cultural studies with different adapted versions of the flow scales aid understanding of cultural similarities and differences in flow experience and contribute to further development of flow theory and its application (Masato, 2007).

One sustained application of the flow concept to sociology was Richard Mitchell's book on mountain climbers (Mitchell, 1983). Mitchell's work suggests, despite its subjectivity, How might contribute to the understanding of many problems central to sociology. In the field of psychology, where the flow concept seems to belong more naturally, the impact has been proportionately greater. A fair amount has been written on flow as a useful idea, as an interesting phenomenon, and as a potentially important aspect of human life.

One of the fields in which the impact of the concept has been substantial is the recently evolved literature on happiness or subjective well-being. In this line of investigation, the flow model is usually seen as the leading activity-based theory of happiness, often traced back to Aristotle's views (Diener, 1984; Diener et al., 1985; Argyle, 1987). As one would expect, researchers working in the field of intrinsic motivation became interested in the studies of flow primarily because for the first time the phenomenon was being looked at in natural settings (deCharms & Muir, 1978; Amabile, 1983; Deri & Ryan, 1985).

2.6.5 The Nature and Dynamics of Flow

The positive correlates and outcomes flow undoubtedly account for some of the interest paid to it in recent years. However, this interest, in a sense, misses the point. From the perspective of individual, the flow state is a self-justifying experience; it is, by definition, an end in itself.

A distinct strand of research can be traced fin-ward from the original study of flow activities. In this work. Interviews have yielded domain-specific descriptions of deep flow in diverse activities: elite and nonelite sport (Jackson & Csikszentmihalyi, 1999; Kimiecik & Harris, 1996), social activism (Colby & Damon, 1992), aesthetic experience (Csikszcntmihalyi & Robinson, 1990), literary writing (Perry, 1999), and scholarly and creative work more generally (Csikszentmihalyi, 1996; Neumann, 2006). These studies confirm how universal the flow state is across different activities. Research also is yielding nuanced pictures of flow within particular contexts. The dynamics of flow arc being studied in domains including sports and games, computer and Web usage, education, and work.

2.6.6 Psychophysiology and Enjoyment (As a Basic Component of Flow)

Damasio (2001) emphasizes the following distinction: Emotions are directly observable and open for investigation by the automatic physiological reactions they induce in the body; feelings are the mental representations of emotions, and private to the person experiencing them. Enjoyment falls to the latter category. According to Damasio, feelings are direct consequences of emotions, although the mechanism is not fully understood. Still, as feeling of enjoyment derived from flow is supposed to be significantly strong (Csikszentmihalyi, 1990) its emotional counterpart should be measurable by physiological changes. Indirectly, the findings of Hatfield et al. (1992) indicate that a behavioral intervention during steady state treadmill running just below ventilatory threshold (VT) can exert a measurable reduction in ventilation in trained runners.

In psychophysiological emotion research it is suggested that all emotions can be located in two-dimensional space of valence and arousal (Lang, 1995). The arousal dimension of emotion is the extent of bodily activation, from low to high. The tone of this activation, for example the difference between rage and exhilaration in case of extreme arousal, is depicted on the valence dimension. According to Lang (1995), enjoyment-or the emotion related to that feeling-is located at high valence and mid-to-high arousal.

Although there is variability in the use of these dimensions, the simple combination of valence and arousal is most often used in psychophysiological research. Arousal is connected to electrodermal activity (EDA, or skin conductance), and valence to facial electromyography (EMG) (Lang et al., 1993).

Measurement of skin conductance, usually on palms of hands, is one of the most often used physiological measurements and a well-established index for emotional arousal (Dawson et al., 2000; Lang et al., 1993). Unlike many other physiological responses, the neural control of eccrine sweat glands – the basis of electrodermal activity - is predominantly under sympathetic nervous system (SNS) which regulates the mobilization of the human body for action (Boucsein, 1992; Dawson et al., 2000). Skin conductance level (SCL) is the measure of tonic EDA.

The use of facial electromyography, or measuring the contraction of facial muscles, is based on the facial expressions associated with emotions, both overt and covert (Lang et al., 1993). Facial expressions can also be rated by observation, but in addition to benefits of reliability and automatization, the EMG has been shown being able to capture activity at a lower level than could be detected visually (Tassinary & Cacioppo, 2000). Themeasurement of the activity of corrugator supercilii (CS, brow muscle, used in frowning), zygomaticus major (ZM, cheek muscle, used in smiling), and orbicularis oculi inferior (OO, muscle below the lower lid, used in widening the eye) muscle areas can be used to discriminate emotional expressions, especially when concentrating on emotional valence instead of discrete emotions (Bradley, 2000). The activity on CS and ZM muscle areas is shown to be connected to negative and positive emotions, respectively (Lang et al., 1993). OO, in turn, has been associated with enjoyment smile and genuine pleasure (Ekman et al., 1990).

Psychophysiological methods are recommended for future studies of flow. Specifically, the time series approach may be particularly viable in examining the temporal aspects of flow, an area currently unexplored. Kivikangas (2006) indicated that cardiac measures should be considered. Heart rate, for example, has been shown to relate to long-term attentional engagement, although it might have interpretative problems in complex situations (Berntson et al., 1996). Respiratory sinus arrhythmia (a measure of heart rate variability) has been suggested as a more reliable index of attention in these situations (Berntson et al., 1994; Porges, 2001).

2.7 Assumptions and Principles of Flow

The flow theory holds that humans have certain basic drives that can influence a person to do something. An example of this occurs when the sugar level in a person's blood falls below a certain point, that person will begin to search for food. Or, a person will quickly learn to do something if that person is rewarded for an action, and will tend to not do those things for which they are punished. However, this alone does not explain why people fast and starve themselves to death, or do exactly the opposite of what they were rewarded for (Csikszentmihalyi, 1988).

In reality, people will do what they want to do, and this is not necessarily dependent directly on outside forces; it depends on priorities established by the needs of the self (Csikszentmihalyi, 1988). In general, people will act in terms of the instructions they receive from these drives. Usually, people want to eat when they are hungry, and will do something if they are rewarded for it. These drives determine the organization of the self, but as soon as the self is operational, it acts on its own to direct behavior. The function of the self is to "mediate between the genetic instructions that manifest themselves as 'instinctual drives' and the cultural instructions that appear as norms and rules" (Csikszentmihalyi 1988). The self-will prioritize the different behavioral instructions and then select the ones it wants to use.

The self-mediates between these sometimes conflicting instructions by means of the consciousness. It is composed of attention, which notices the information available; awareness, which interprets this information; and memory, which stores the information (Csikszentmihalyi 1988). The content of consciousness is experience, which is “the sum of all the information that enters it, and its interpretation by awareness”.

Attention is the means by which information appears in consciousness. However, humans are limited in the amount of information that can be discriminated. Attention is the medium that makes events occur in consciousness, and can be thought of as “psychic energy” (Csikszentmihalyi, 1988). Each conscious activity a person does requires a certain amount of this psychic energy.

Awareness designates all those processes that occur after a bit of information is attended to. It includes recognizing the stimulus, categorizing it in terms of previous information, and disposing of it by remembering it or forgetting it (Csikszentmihalyi, 1988). The more important processes of awareness include thought or cognition, feeling or emotion, and conation or volition. Cognition recognizes the information and relates it to each other; emotion defines the attitude that is taken to the information that is being processed; and volition is what keeps the attention focused on the information instead of moving on to other targets (Csikszentmihalyi, 1988).

Memory is simply the process that stores the information that passes through consciousness so that it can again be recalled. These three subsystems of consciousness - attention, awareness, and memory - act as a buffer between the genetic and cultural instructions received and behavior (Csikszentmihalyi, 1988). Because of this transformation of physiological processes into subjective experience, consciousness makes it possible to “gain control over the anonymous instinctual forces”.

As soon as the self has established itself in consciousness, its main goal is to ensure its own survival (Csikszentmihalyi, 1988). To this end, “attention, awareness, and memory are directed to replicate those states of consciousness that is congenial to the self, and to eliminate those that threaten its existence”.

Therefore, the self has its own set of goals that are placed in a hierarchy, and in effect become the structure of the self (Csikszentmihalyi, 1988). Each new bit of information that makes its way into a person’s awareness is prioritized by this hierarchy. Most of the goals are established based on genetic and social instructions, but the consciousness has some degree of autonomy in this regard.

Any state that conflicts with an individual’s goals is termed psychic entropy (Csikszentmihalyi, 1988). It is similar to the role that noise plays in the basic communication model. It can be experienced as fear, boredom, apathy, anxiety, confusion, jealousy, etc. depending on the kind of goals the information is in conflict with (Csikszentmihalyi, 1991). This state of psychic entropy is similar to Festinger’s cognitive dissonance, but Festinger does not include the concept of the self, and it only refers to the cognitive aspects of an individual (Csikszentmihalyi, 1988).

The state that results when all the contents of consciousness are in harmony with each other, and with the individual’s goals that define the self, is called psychic negentropy, optimal experience, or flow (Csikszentmihalyi, 1975). The subjective experiences of pleasure, happiness, satisfaction, and enjoyment are manifestations of flow. Because the self-sets up goals to maintain itself, and because flow is a state where a self is most congruent with its own goal-directed structure, flow becomes one of the central goals of the self (Csikszentmihalyi, 1988). This is referred to as the “teleonomy of the self”, or the goal seeking tendency that shapes the choices that are made among the alternatives (Csikszentmihalyi, 1988).

2.8 Fundamental Dimensions of the Flow Experience

An activity that has relatively clear goals and that provides rather quick and unambiguous feedback is a likely candidate for flow (Csikszentmihalyi, 1988). This allows the person who is involved in the activity to know what needs to be done, and how they are doing. A game without rules or a way to assess performance is impossible to play (Csikszentmihalyi, 1988).

There is a sense of control over the outcome of the activity, a distortion of time, a loss of the awareness of self and everyday problems, and a feeling of transcendence, or oneness with the activity (Csikszentmihalyi, 1988).

The last stage of the flow experience involves the transforming the entirety of one's life into a single flow activity, with unified goals that provide a constant purpose (Csikszentmihalyi, 1991). By doing this, it is possible to give meaning to one's entire life, and therefore achieve, as close is as humanly possible, optimal experience (Csikszentmihalyi, 1991).

Flow is an optimal psychological state that has been described at length by Csikszentmihalyi (1990, 1993) and adapted to sport and physical activity settings by sport and exercise psychology researchers interested in identifying and understanding the nature of the experience in these competitive and recreational sport environments (Catley & Duda, 1997; Jackson, 1992; Jackson & Roberts, 1992; Kowal & Fortier, 1999; Stein et al., 1995). Understanding the experience of the state of flow in sport settings has been the focus of Jackson's (Jackson, 1996; Jackson & Marsh, 1996) research in this area. The present study is an attempt to further describe and explain the process of flow as it may occur in physical activity settings.

Flow has been described by Csikszentmihalyi (1990, 1993) as comprising the following nine dimensions:

1. Challenge-Skill balance. In flow, there is a feeling of balance between the demands of the situation and personal skills.
2. Action-Awareness Merging. Involvement is so deep that there is a feeling of automaticity about one's actions.
3. Clear Goals. A feeling of certainty about what one is going to do.
4. Unambiguous Feedback. Immediate and clear feedback is received, confirming feelings that everything is going according to plan.
5. Concentration on Task at Hand. A feeling of being really focused.
6. Sense of Control. The distinguishing characteristic of this feeling in the flow state is that it happens without conscious effort.
7. Loss of Self-Consciousness. Concern for the self disappears as the person becomes one with the activity.

8. Transformation of Time. Time can be seen as passing more quickly, more slowly, or there may be a complete lack of awareness of the passing of time.
9. Autotelic Experience. Csikszentmihalyi (1990) describes this as the end result of being in flow, a feeling of doing something for its own sake, with no expectation of future reward or benefit.

Jackson (1996) found support for these dimensions in a qualitative analysis of elite athletes' flow descriptions. Jackson & Marsh (1996) further argued that a multi method approach is need to understand flow, incorporating both qualitative and quantitative research. In particular, they urged the importance of establishing the validity of the various constructs said to underlie the flow experience and relating these dimensions to other psychological states.

Young (1999) has made a qualitative analyses of female professional tennis players which narratives of flow experiences revealed a high degree of correspondence with the eight elements posited by flow theory (i.e. challenge-skill balance, concentration, action-awareness merging, clear goals and feedback, loss of self-consciousness, paradox of control, transformation of time, and autotelic experience).

The purpose of the investigation of Murica et al. (2008) was to examine the relationships among perceived motivational climate, individuals' goal orientations, and dispositional flow, with attention to possible gender differences. The perceptions of task-involving and ego-involving motivational climates were positively and significantly linked to general dispositional flow. No meaningful differences were found between males and females in general dispositional flow.

Massimini & Carli (1988) divided "challenge" and "skill" into low, medium, and high three levels and combined them into eight channels of the eight state flow model. These eight states are: Flow: high challenge with high skill; Arousal: high challenge with medium skill; Anxiety: high challenge with low skill; Control: medium challenge with high skill; Worry: medium challenge with low skill; Boredom: low challenge with high skill; Relaxation: low challenge with medium skill; Apathy: low challenge with low skill.

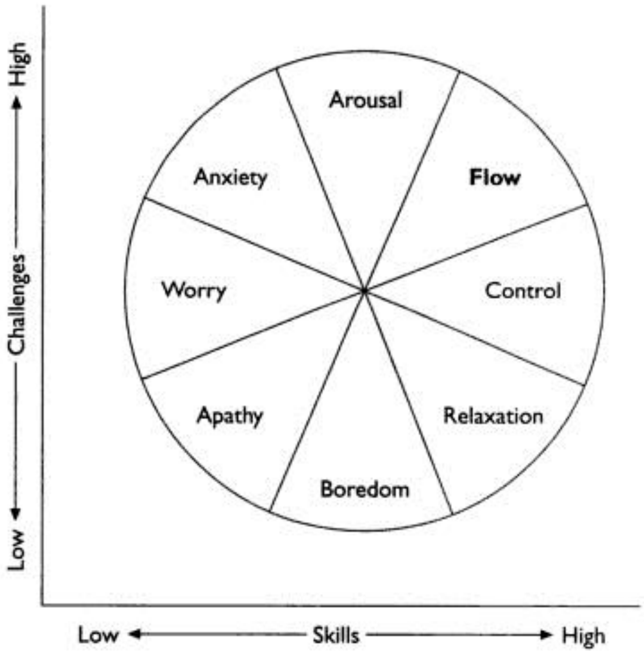

Fig. 5: Flow and other states related to levels of skill and challenge. Adapted from Csikszentmihalyi (1997).

2.9 Importance of the Flow Experience for Elite Athletes

Moneta & Csikszentmihalyi (1996) examined the flow experience in various contexts, indicating that “the balance of challenges and skills has a positive effect in some contexts and little or no effect in others”. In other words, the challenges of the competition and the skills of the athlete are two subjective experiential variables, which exert a dependent effect on each other or independent effect on the quality of experience. Before or during competition, challenge and skills level are dynamic in nature, depending on individual qualities (e.g. experience, mental preparation, physical preparation) or situational characteristics (e.g. importance of competition, difficult opponent). Stein & colleagues (1995) reported that in a competitive environment the level of a person’s perceived skills is positively related with the quality of experience, whereas in a learning environment both the person’s perceived skills and the challenges are related to the quality of experience.

Jackson & Roberts (1992) examined the balance between challenges of the competition and athletes’ skills during their best and worst performances. The results revealed large differences in mean scores between challenges and skills in athletes’ worst performances, whereas no differences were found in their best performances. Furthermore, the mean values of challenges and skills were higher.

Achieving peak performance is an all-important goal for competitive athletes and coaches, and flow can facilitate such outcomes. The mind-set accompanying flow tends to push a person to his or her limits, and this is one reason why flow is so important to athletes seeking to do their best.

As athletes and coaches know all too well, it is difficult to have the body perform to high levels when the mind is not focused. While flow is important for those seeking peak performances, flow experiences are also rewarding for their own sake, regardless of the outcomes they may produce. When too focused on outcomes, you can easily miss the experience If you are so concerned about winning an event, you may miss the mental state that is likely to help bring it about. This can be disastrous for performance (Jackson & Csikszentmihalyi, 1999).

2.9.1 Flow Experience and Athletic Performance

The relationship between the flow concept and sport performance is of great interest for athletes, coaches, and applied sport psychology consultants. Flow has been examined either as a phenomenon or as a concomitant of performance (Jackson & Csikszentmihalyi, 1999; Jackson & Wrigley, 2004), with a close relationship suggested between peak performance and flow (Ravizza, 1977; Jackson, 1992, 1999; Jackson & Roberts, 1992; Jackson et al., 1998; Jackson et al., 2001).

Examining the similarity or overlap between peak performance and flow, Privette (1983) and Privette & Bundrick (1991) described the distinguishing and similar characteristics of these concepts. They concluded that flow is an intrinsically rewarding experience, whereas peak performance is characterized as a person’s optimal functioning. In addition, Privette & Bundrick (1997) reported that peak performance is characterized as playful, fun, and fulfilling, whereas flow is marked by fun and enjoyment.

Based on the aforementioned, the flow concept cannot be used interchangeably with the terms of peak performance and peak experience, because one might be in flow without necessarily achieving these other outcomes. When an athlete experiences peak performance, however, he or she appears to be in flow. Csikszentmihalyi & LeFevre (1989) state that flow experience constitutes a combination of characteristics that typify peak performance and peak experience, whereas Jackson (Jackson & Roberts, 1992) proposed that flow might be a precursor to, or the psychological process underlying, peak performance.

Flow is associated with high levels of performance and positive experience. Jackson's qualitative content analyses of best performances (1992, 1995, 1996) and Jackson & Roberts's (1992) quantitative results showed that athletes' best performances were associated with flow characteristics. Athletes in their best performances indicated higher flow ratings than in either their worst performances or when they generally compete (Jackson & Roberts, 1992). Factors such as total commitment, clearly defined goals, feedback about how well an athlete is performing, concentration on performing the activity, task-relevant thoughts, sense of control, and feelings of fun, confidence, and enjoyment were among the most frequent psychological characteristics that athletes mentioned during high levels of performance (e.g. Gould et al., 1992).

Kimiecik & Stein (1992) suggested that to better understand the flow experience researchers need to examine subjective states along with objective outcomes. Jackson & colleagues (2001) attempted to examine relationships between flow and both subjective and objective criteria. Measures of performance included finishing position and perceived success, and associations with flow were found with both types of measures.

To date, despite the great interest in examining the psychological issues of athletes' performance, sport psychologists have focused mainly on the negative factors of athletes' experience, such as anxiety and stress, ignoring the positive psychological qualities underlying elevated levels of performance. Identifying the relation between optimal psychological states and athletes' performance might be helpful to the development of mental training programs to help promote optimal mental states. From a theoretical point of view, the examination of the relationship between the orthogonal model and flow experience in sports has not been examined. In addition, the study of flow experience and sport performance to date has been based primarily on athletes' subjective perceptions and interviews during high and low levels of performance, as well as on the comparison of successful and less successful performances (Jackson, 1992, 1995, 1999; Jackson & Roberts, 1992).

Therefore, it seems important to examine the independent relation of challenge and skills, as well as challenge skill ratios, with flow experience and athletes' performance. Moreover, the examination of the relation between flow factors and both subjective and objective measures of performance might provide more comprehensive information about the psychological qualities that underlie sport performance, from a quantitative point of view. Thus, the purposes of the current study were to examine (a) the differences in Flow State Scale (FSS) subscales between the four experiential states of the orthogonal model (apathy, anxiety, relaxation, and flow); (b) the relationship between challenge, skills, and flow experience; and (c) the relationship between flow experience and athletes' performance.

2.10 Reliability and Validity of Flow Experience Assessing in Sport

The validity of this theory is one of the strongest arguments to give it high marks according to Littlejohn's criteria. According to Csikszentmihalyi (1988), anywhere the quality of human experience is an issue, flow becomes relevant. It has been demonstrated by empirical studies that flow is a panhuman phenomenon and can be generalized across many situations. Flow has offered a reason for why some people can become completely engrossed in their "work", but be completely bored in their "leisure". In fact it has given new definitions to the concepts of work and leisure.

It also helps to explain some of people's motivations for their actions and thoughts, or stated more simply, why people do the things they do. Csikszentmihalyi (1988) feels that flow theory is not so much concerned with why people do the things they do, but with how flow feels and how it can be controlled. It has switched attention away from the issue of causality to issues of consequence; the purpose now is not so much to understand what accounts for a behavior, but to know what psychic rewards bring it about (Csikszentmihalyi, 1988).

The conclusions reached in Boredom and Anxiety were based on a very select group of people and was primarily in a laboratory setting. To study flow in a natural context, the Experience Sampling Method (ESM) was developed (Csikszentmihalyi & Larson, 1987). They provided respondents with an electronic pager, or beeper, and a survey questionnaire booklet. The investigators beeped the respondents randomly via radio signals seven times a day between 8 AM and 10 PM for a one week period. Each time the respondents were beeped, they filled out a survey form. By the end of the week, the researchers were able to compile a systematic description of the respondent's activities for the day, as well as the personal experiences and dimensions of consciousness of the respondents (Csikszentmihalyi, 1988).

The results of this study showed that almost any activity in daily life can produce a flow like experience. Also, it showed that activities like studying and schoolwork were conducive to flow the same as typical leisure activities were. It was also shown that television viewing was the activity that produced the greatest amount of apathy in an individual (Csikszentmihalyi & Larson, 1987; Csikszentmihalyi, 1988).

To examine whether flow (Csikszentmihalyi, 1990) is experienced across sports and recreational and pathological gambling, they assessed a sample of 511 college students. A LISREL model showed that flow was positively associated with general emotional well-being (Wanner et al., 2006).

The results of (Asakawa, 2004) showed that high challenge/high skill situations created an optimal state of mind for the Japanese college students, as flow theory postulates. The findings from this study provided strong support for the validity and reliability of the JFSS-2 and JDFS-2 in assessing flow experiences in physical activity for Japanese adults. In addition, this study indicated that the Japanese versions of the flow scales are useful instruments for cross-cultural research (Kawabata et al., 2008). This study suggests that athletes' flow dispositions and mental skills adoption could be differentiated using mindfulness. The findings have implications towards the understanding of flow and mental skills adoption within sport psychology (Kee & Wang, 2008).

The study of (Fournier et al., 2007) provided support for the factor structure of the French version of the FSS-2 and for the invariance of the flow construct across languages. Flow state is significantly associated with goal attainment and the relationship is equivalent across athletes' levels of competition.

The study of Rheinberg & Vollmeyer (2003) presents a technique how to manipulate flow-experience via the computer game "ROBOGUARD". Under experimentally controlled conditions all parameters of the game and the situation were kept constant except the difficulty level the participants had to play on. Flow was assessed with the Flow Short Scale (FKS, Rheinberg et al., 2003).

As predicted we received the highest Flow score on the medium/optimal level in comparison with an easy and difficult level (d > 1.0). According to the cognitive-motivational model of learning, performance depends on the quality and quantity of learning activities as well as on the functional state during learning. We assumed that the flow-experience is one indicator of the functional stat. The results of both studies indicate that flow-experience is an indicator of the functional state relevant for learning outcome. The general pattern of the results also fits nicely with the proposed relationships of the cognitive-motivational model of learning (Engeser et al., 2005).

The two studies of Stoll & Lau (2005) reported here analyze the associations between flow-experiences and performance in 234 marathon runners and examine whether a fit between demand and ability is a necessary precondition for flow experiences to emerge. There were no correlations between performance and flow in average-performance runners (3-4 hour finishing times). By multiple-regression analysis (Stavrou et al., 2007) demonstrated significant prediction of athletes' performance based on flow experience during competition. Future research should examine the relationship between flow, athletes' performance, and additional dispositional and state variables.

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Csikszentmihalyi’s flow models are outlined and examined with particular reference to perceived levels of challenge and skill. It is suggested that an insight into the nature and characteristics of such optimal experiences can contribute to our understanding of why adventurous activities are intrinsically motivating. Such an understanding can assist practitioners in enhancing the learning experiences and opportunities for development of each individual participant (Boniface, 2000).

Jackson (1992) observed that the skaters placed very high value on Row-like states, and their descriptions of what was occurring during optimal skating experiences paralleled many of the characteristics of flow described by Csikszentmibalyi (1975, 1990). Drawing on the experience of elite athletes may enhance understanding of flow states as they occur in sport.

Kimiecik & Stein (1992) addressed that athletes' subjective states and experience generally are neglected by sport psychology research due to an emphasis on performance and competitive outcomes. Two major conceptual questions were addressed: What is flow and how do flow states occur? The latter question was discussed taking into account both the person and situation factors that may underlie athletes' flow experiences.

Confirmatory factor analyses supported the nine scales. Consistent with the theoretical basis of the Flow State Scale (FSS), there was also support for a hierarchical model in which one global (higher order) flow factor explained correlations among the nine first-order FSS factors (Jackson & Marsh, 1996).

The Subjective Exercise Experiences Scale (SEES) may represent a useful starting point for more thoroughly examining exercise and subjective responses at the global level, and these dimensions of the scale may represent possible antecedents of specific affective responsively (McAuley & Courneya, 1994).

Jackson & Eklund (2002) estimate reliability ranged between .80 to .92 for the Flow State Scale-2 (FSS-2) and .78 to .86 for the Dispositional Flow Scale-2 (DFS-2). The scales are presented as ways of assessing flow experienced within a particular event

(FSS-2) or the frequency of flow experiences in chosen physical activity in general (DFS-2).

The Rasch analyses provide useful additional information about the areas of the flow continuum tapped by the items and scales of the FSS and, in so doing, help to confirm the construct validity and generalizability of the scale itself (Tenenbaum et al., 1999). Sugiyama & Inomata (2005) indicated that the psychological states leading up to flow state were placed into six categories: relaxed, self-confident, highly motivated, completely focused, lack of negative thoughts and feelings, and extremely positive. Relaxed, self-confident, and highly motivated were reported by most of the athletes, suggesting they are primary elements for an optimal experience.

Jackson & Roberts (1992) found these associations suggest that investigating positive performance states from a motivational standpoint may lead to greater understanding of the underlying conceptual bases of peak athletic performance.

These results are consistent with other research with Olympic athletes and suggest that precompetitive states play a critical role in competitive performance and the win created significant and long-lasting change to most athletes' lives. (Gould et al., 1992[a]; Jackson et al., 1998). These results are consistent with other research on Olympic athletes and with peak performance, peak experience and flow research (Gould et al., 1992[b]).

The psychological antecedents of flow for sport participants remain unidentified, as neither goals, competence, nor confidence predicted the flow experience (Jackson, 1995). College athletes appear to have similar experiences of flow states, regardless of gender or sport type. Results are discussed in terms of the importance of examining both qualitative and quantitative aspects of flow occurrence in athletes (Russell, 2001). Correlational and multivariate analyses were conducted to examine psychological correlates of state and trait flow. Patterns of relationships were found between flow and perceived ability, anxiety, and an intrinsic motivation variable (Jackson et al., 1998). Those dimensions of flow most represented across the group's data were the autotelic experience of flow, total concentration on the task at hand, merging of action and awareness, and the paradox of control. The analyses provided a detailed, sport-specific picture of flow state in elite athletes (Jackson, 1996). In a recent study, Young (1999) examined flow experiences of 31 Australian professional female tennis players. Adopting dual flow theory and reversal theory frameworks, the study found evidence to support both theoretical conceptualizations of flow.

2.11 A Cognitive Neuroscience Perspective on Sport Performance

A number of investigators have supported the notion that high-level athletic performance is characterized by economy of metabolic, physiological, and kinematic processes (i.e. motion) (deVries, 1968; Daniels, 1985; deVries & Housh, 1994; Hatfield & Hillman, 2001). This means that skilled athletes accomplish their work and perform their tasks with minimal effort.

Phenomenological reports of high-performance athletes are supportive of such a position. Williams & Krane (1998) described a number of psychological qualities associated with the ideal performance state such as effortlessness, little “thinking” during performance, and an involuntary quality to the experience. Such subjective attributes are also consistent with the classic notion of automaticity of skilled motor behavior advanced by Fitts & Posner (1967). On the other hand, negative affect and the associated cognitive activity reduce efficiency of movement, thereby degrading the quality of motor performance (Beuter & Duda, 1985; Weinberg & Hunt, 1976). In this regard, Beuter & Duda (1985) observed alterations in the kinematic qualities of lower limb movement in young children during walking when they were subjected to psychological stress. The authors stated that the task of stepping, which was controlled automatically in a low-stress condition, became less smooth and efficient as volitional control took over under high stress.

Alternatively, the cognitive neuroscience perspective does offer insight as to how psychological states affect the quality of motor performance. Cognitive neuroscience, an area of behavioral science, in which mental processes are explained In terms of neurobiology, typically uses neuroimaging or “brain imaging” tools to address research issues. As illustrated schematically in figure 6, the cortical association areas that underlie cognitive and affective processes are intricately interconnected to the “motor loop” mediated by the basal ganglia. The motor loop is composed of the striatum, globus pallidus and the ventrolateral nucleus of the thalamus, which then projects to the motor cortex and enables depolarization of the appropriate cell bodies for ultimate activation of skeletal muscle motor units (Kandel & Schwartz, 1985; Bear et al., 2001).

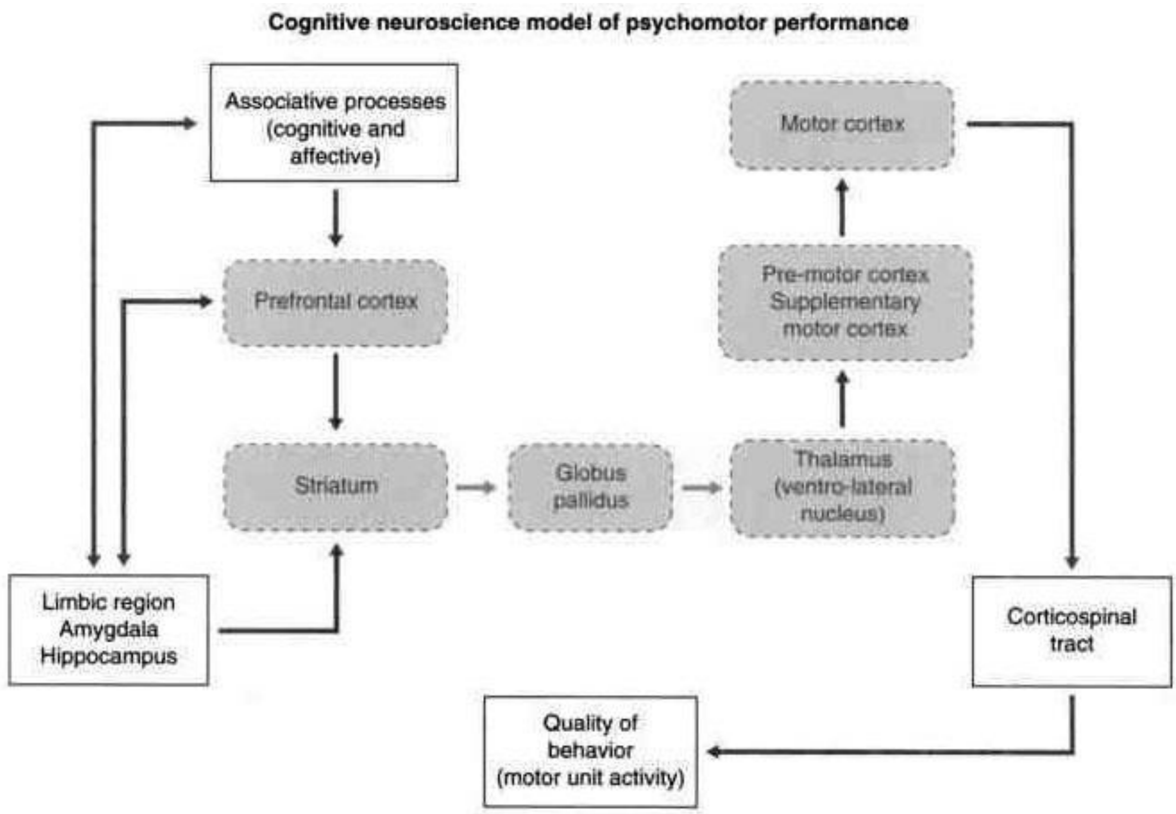

Fig. 6: Various component structures involved in the interplay between cognitive (association), emotive (limbic lobe), and motor processes that result in motor behavior (motor unit activation). The motor loop is shown by the structures connected with the broken lines.

2.11.1 The Transient Hypofrontality Hypothesis

There was a misconception since a short time that blood flow to brain increases during exercise. This is incorrect, so global cerebral blood flow to the brain is constant, approximately 750 ml/min, regardless of mental or physical activity. At rest, the brain gets ca. 15% of total cardiac output per beat. As exercise intensity increases, cardiac output is redistributed (mostly to muscles) and the brain receives a lower percentage per beat. At maximal intensity, the brain gets ca. 4% of cardiac output per beat. However, this reduction is precisely offset by the overall increase in total cardiac output (the heart beats ca. 4 times faster), resulting in a steady perfusion rate. Global oxygen and glucose uptake is also constant.

According to Kubo et al. (2008), in specific manner, an increase of prefrontal cortex blood flow during the performance of the computer version trail making test. This hypothesis explains that the distribution of blood input inside the brain is differentiated.

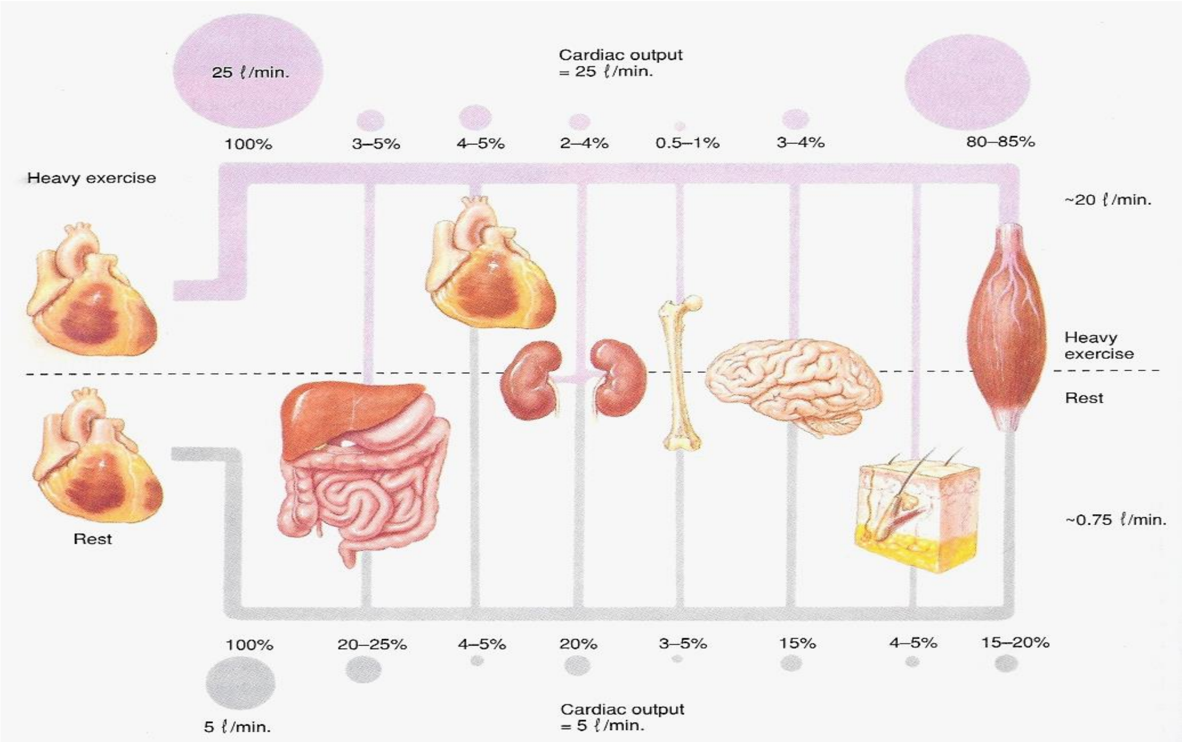

Fig. 7: Cardiac output in percentages to human body organs at rest (5 l/min) and at maximal intensity (25 l/min).

The brain codes intensity by the rate of neuronal firing. An increased rate of firing increases a neuron's metabolic needs. Thus, low-intensity exercise is less likely to force the brain to shift its limited resources away from the PFC. Conversely, exercise of high intensity introduces a second limiting factor, as intense exercise cannot be maintained long enough by the cardiovascular system to tax the brain's resources.

However, a moderate workload would be associated with a considerable increase in neuronal firing rates in a majority of brain tissue that can also be sustained for a long period of time. Thus, exercise intensity at the anaerobic threshold, is the effort most conducive to force a reallocation of resources at the expense of higher cognitive and emotional structures such as prefrontal areas. This fits well with clinical data showing that exercise in the moderate, aerobic range is most beneficial to mental health, a fact that has yet to be adequately addressed by neurochemical theories.

Dietrich & Sparling (2004) in their results showed that during exercise performance on tests demanding prefrontal-dependent cognition was impaired, while at the same time, cognitive processes requiring little prefrontal activity were unaffected.

Cognitive control processes enable us to adjust our behavior to changing environmental demands. Although neuropsychological studies suggest that the critical cortical region for cognitive control is the prefrontal cortex, neuroimaging studies have emphasized the interplay of prefrontal and parietal cortice (Brass et al., 2005). It is proposed that a necessary prerequisite to the experience of flow is a state of transient hypofrontality that enables the temporary suppression of the analytical and meta-conscious capacities of the explicit system (Dietrich, 2004).

2.11.2 Interruption and Flow

We've often suggested that when people experience adversity in trying to move toward their goals, they periodically experience an interruption of their efforts, to assess the likelihood of a successful outcome (e.g. Carver & Scheier, 1981, 1990[a], 1990[b]). In effect, people suspend the behavioral stream, step outside it, and evaluate in a more deliberated way than occurs while acting. This may happen once, or often. It may be brief, or it may take a long time.

What circumstances induce this interruption and assessment? Little evidence exists on this question, but it's easy to speculate. People often engage in deliberative assessment of outcome likelihood before undertaking actions (cf. Gollwitzer, 1990). This is particularly likely if the person knows ahead of time the task is going to be hard. Indeed, in such cases the person's evaluation of the likelihood of success may be a critical determinant of the decision to undertake the behavior.

Interruption can also occur in the midst of behaving, if the person encounters obstacles or impediments along the way. The experience of deceleration may play an important role in such cases. That is, it seems reasonable that a shift toward more negative feelings is often the cue that triggers interruption of ongoing action and causes people to consciously judge the chances of their eventual success. This is consistent with characterizations of the experience of surprise, which we argued relates to the acceleration-deceleration experience. For example, Tomkins (1984) said that surprise represents sort of a “circuit breaker or interrupter mechanism”.

One might contrast the experience of interruption with that of flow (Csikszentmihalyi, 1990). Flow seems to be a condition in which behavior is never interrupted for an expectancy assessment. Perhaps the flow experience reflects a velocity function that's smoothly tracking its reference value. This would fit with descriptions of the flow experience that emphasize the close fit between the demands of the environment and the person's competencies, such that the person is fully engaged in behaving, but is never pressed to wonder whether the behavior can be successfully maintained.

Although we need to understand how to enhance the likelihood of flow occurrence, it is equally important to understand what factors may prevent or disrupt (Jackson, 1995). These factors are identified in “Factors That Prevent and Disrupt flow”. Despite some consistency in what prevents what disrupts flow’s occurrence, individuals do experience differences between these situations. The factors athletes cued most often as preventing flow were less than optimal physical preparation, readiness, and environmental or situational conditions; the reasons they gave most often as disrupting the flow state were environmental and situational influences.

2.10.3 Interruption and Assessment

We've suggested that when people experience adversity in their attempts to move forward toward their goals, they periodically interrupt their task-directed efforts to assess the likelihood of a successful outcome (e.g. Carver & Scheier, 1981, 1990[a], 1990[b], 1995). In effect, they suspend the behavioural stream they're in the midst of, step outside it, and evaluate the likely outcome of continued efforts, in a more deliberated way than takes place while acting. This may happen once, or it may happen often. It may constitute only a momentary check, or it may represent a more extended thinking through of the situation. The outcome of this process is a sense of favourable versus unfavourable expectancy concerning the desired outcome. There are several questions that might be asked about this postulated interruption and assessment. One question is what circumstances induce it? Clearly such interruption is not inherent in all activity. For example, the experience of “flow” (Csikszentmihalyi, 1990) seems to be one in which behaviour occurs smoothly, with no thought at all being given to the question of whether the outcome of the behaviour will be as desired. Interruptions probably occur when obstacles are encountered, particularly unexpected obstacles. Indeed, it may often be the sudden halt to progress that such obstacles can create that causes people to stop and wonder, if only for a moment, whether they will be able to get around the roadblock they are facing. Though interruptions often occur in the midst of behaviour, they can also come before the action commences. People often engage in deliberative assessment of outcome likelihood before undertaking behaviours (cf. Gollwitzer, 1990), particularly if it's known ahead of time that the task is going to be difficult. Indeed, in such cases the perceived likelihood of success may be one determinant of the decision whether to undertake the behaviour or not. Individual differences surely exist in the tendency to engage in expectancy assessment. Some people are prone to step outside the behavioural stream and lapse into assessment repeatedly (cf. Kuhl, 1981, 1985, concept of state orientation), the virtual opposite of a flow experience. Others only rarely take this step. These differences in the process of questioning seem to be tied to the individual's level of confidence. A fundamental effect of confidence seems to be to pre-empt the question of whether an action (or a program of action) will be successful. The issue is simply less likely to arise for a confident person than for a person with greater doubts. Here is one simple place in the structure of action where relative confidence may relate to differences in cognitive interference. A second question about expectancy assessment concerns the source of the expectancies that emerge from it. In this process of more consciously assessing the probability of the desired outcome, people presumably depend to a large extent on memories of prior outcomes in similar situations. They may also consider a number of other issues. For example, an important question is what additional resources they might bring to bear on the problem they're confronting (cf. Lazarus, 1966). Another possibility is whether there is an alternative approach to the problem they might take. People also make use of social comparison information in assessing what the eventual outcome might be (e.g. Wills, 1981; Wood et al., 1985; Wood, 1989).

Some of the influences on the expectancies that emerge stein from variations in the situation. Others are a product of personality. Dispositional biases can have a large influence on people's expectations, even when the situation being confronted is the same for everyone. For example, the personality disposition of optimism versus pessimism represents a dimension of generalized expectancies for the occurrence of good versus bad outcomes in one's future (Scheier & Carver, 1985, 1992; Scheier et al., 1994). Stable biases in expectancies also play a role in cognitive theories of vulnerability to depression (e.g. Beck, 1972).

2.10.4 Factors That Prevent and Disrupt Flow

Although we need to understand how to enhance the likelihood of flow’s occurrence, it is equally important to understand what factors may prevent or disrupt it (Jackson, 1995). These factors are identified in “Factors That Prevent and Disrupt Flow”, see figure 8. Despite sonic consistency in what prevents and what disrupts flow's occurrence, individuals do experience differences between these situations. The factors athletes cited most often as preventing flow were less than optimal physical preparation, readiness, and environmental or situational conditions: the reasons they gave most often as disrupting the flow state were environmental and situational influences. Professionals can try to structure the environment and provide feedback to maximize the possibility of athletes reaching and maintaining a flow state. However, participants themselves must be aware of the factors that influence the occurrence of the flow state so that they can mentally and physically prepare for competition and physical activity accordingly. They should distinguish factors that are under their control and that they can change (e.g. physical or mental preparation, focus of attention, negative self-talk) from those they can't control (e.g. crowd responses, coach feedback, weather and field conditions, and behaviour of competitors). For example, an athlete can't control a hostile crowd, but she am control how she reacts both mentally and emotionally to the crowd. Similarly, a physical therapist can't control patients' attitudes or how crowded a clinic is, but he can strive to maintain a positive attitude in his interactions with clients. Finally, increasing psychological skills such as arousal regulation, emotion management, and thought control increases one's likelihood of experiencing flow.

Factors That Prevent and Disrupt Flow

Preventive Factors

- Nonoptimal physical preparation and readiness
  - Injury
  - Fatigue
  - Not feeling good physically
- Nonoptimal environmental or situational conditions
  - External stresses
  - Unwanted crowd response
  - Uncontrollable influences of the event
- Lacking confidence or a negative mental state
  - Negative thinking
  - Self-doubt
  - No control of mental state
- Inappropriate focus
  - Thinking too much
  - Worrying about what others are doing
  - Frustration with teammate's effort
- Problem with precompetitive preparation
  - Poor precompetitive preparation
  - Distraction before competition
  - Interruption to precompetitive preparation
- Lacking motivation to perform
  - No goals
  - Lack of challenge
  - Low arousal or motivation
- Nonoptimal arousal level before competition
  - Not being relaxed
  - Feeling too relaxed
- Negative team play and interactions
  - Team not performing well
  - Not feeling part of the team
  - Negative talk within the team
- Performance going poorly
  - Unforced errors
  - Poor technique
  - Things not going as planned

Disruptive Factors

- Nonoptimal environmental and situational influences
  - Stoppage in play
  - What opposition is doing
  - Negative referee decisions
  - Inappropriate, negative, or no feedback
- Problems with physical readiness or physical state
  - Lack of physical preparation
  - Injury during the competition
  - Fatigue
- Problems with team performance or interactions
  - Negative talk on the field
  - Team not playing well
  - Lack of team interactions
- Inappropriate focus
  - Worrying about competitor's ability
  - Daydreaming
  - Loss of concentration
- Doubting or putting pressure on self
  - Self-doubt
  - Putting pressure on self

Fig. 8: Factors that prevent and disrupt flow (Weinberg & Gould, 2011).

2.10.5 Objective Measurement

The ESM yields a corpus of moments in flow, particularly when large numbers of experience samples are collected, but necessarily interrupts the flow experience. Custodero (1998) triangulated interview and observational data to construct a behavioural measure of flow during young children's musical performance. While her primary motivation was to devise a measure of flow for a population with limited capacity to report inner states, her work represents one of the few efforts to identify behavioural markers of flow. The technique is painstaking and time-intensive, however. With colleagues including Fredrik Ullen, one of our current goals is to identify physiological markers of flow that would permit tracking of the dynamics of flow without disrupting it.

ESM research suggests that enjoyment and involvement are associated with significantly lower salivary cortisol levels than expected for time of day (Adam, 2005), implying lower stress levels and lower blood pressure.

2.11 Universality of the Sport Zone

Several researchers (e.g. Loehr, 1995; Cooper, 1998) have suggested that the zone or flow state is a universal phenomenon for athletes across sports. To examine this, Young (1999) compared flow experiences of 31 Australian professional female tennis players with similar experiences reported by Jackson’s (1993, 1996) 28 elite athletes (14 male and 14 female, with an equal number from Australia and New Zealand, representing seven sports [four athletes per sport], which included track and field, rowing, swimming, cycling, triathlon, rugby and field hockey). To provide the basis for such a comparison, Young replicated a procedure adopted by Jackson and asked tennis players to: (a) relate “an experience of a time that stood out from average, one involving total absorption and which was rewarding in and of itself”, and (b) respond to the Experience Questionnaire (Privette, 1984). It was predicted that the tennis players and elite athletes, representing different nationalities, status (professional/non-professional) and sports would describe similar experiences and rate the importance of experiential correlates (e.g. thoughts, feelings, meaning) of flow similarly if such experiences were universal.

For a fuller understanding of the differences between tennis players and elite athletes on the importance of experiential correlates of flow, responses to individual items in the Experience Questionnaire (Privette, 1984) were compared. Following the procedure adopted by Yeagle et al. (1989) to identify differences between groups on the importance of experiential correlates of the peak experience, a series of t-tests were conducted in which mean item scores for each group of athletes were compared. The results of these tests, after being adjusted by the Bonferroni correction for multiple tests, are reported in Table 1, with items listed in abbreviated form and in the order reported by Jackson (1993).

Table 1: Mean Scores and t-values for Young's (1999) Tennis Players and Jackson's (1993) Elite Athletes from Other Sports on Experience Questionnaire (Privette, 1984) Items.

Item	**Tennis players**	**Elite Athletes**	**t-value**
Clear inner process	4.50	4.64	-1.05
Felt all together	4.61	4.89	-2.51
Awareness of power	4.23	4.50	-1.89
Clear focus	4.77	4.93	-2.04
Strong sense of self	4.52	4.25	2.19
Free from outer restrictions	4.18	3.65	**4.65***
Need to complete	4.39	4.82	-3.00
Absorption	4.68	5.0	**-3.32***
Intention	4.61	4.86	-2.46
Personal responsibility	3.32	4.21	**-4.04***
Overwhewlmed other senses, thoughts	4.06	4.29	-1.41
Process "clicked"	4.52	4.50	0.11
Personal understanding, expression	3.23	3.26	-0.16
Actions, thoughts spontaneous	4.58	3.70	**7.90***
Event was practiced	3.13	4.46	**-5.45***
Performance	6.44	6.57	-1.44
Fulfillment	4.87	4.93	-0.97
Intrinsic reward	4.52	4.57	-0.41
Loss of self	1.83	2.00	0.93
Spiritual	2.71	2.86	-0.59
Loss of time and space	2.74	3.46	-2.42
Unity of self and environment	3.38	3.86	-1.96
Enjoyed others	2.03	2.57	-2.21
Prior related involvement	2.90	4.86	**-7.71***
Fun	4.29	4.04	1.49
Action or behavior	4.06	5.00	**-4.76***
Goals and structure	3.52	5.00	**-6.55***

Notes:

1. Values of 3.5 or more indicate endorsement.
2. *Significant at an alpha level of 0.05 divided among 27 comparisons (Bonferroni correction for multiple tests). With no significant differences between tennis players and elite athletes from other sports on the Experience.

2.12 Critique and Evaluation of Flow

It didn't come across any formal criticism of flow except those referenced by Csikszentmihalyi in his books and Sun's (1987) comparison of Yu philosophy and Csikszentmihalyi's theory of flow. Some critics argue that the flow theory is too much of a Western concept, and that it applies more to men than women. By this, they imply that it is too active and goal directed to represent a panhuman trait (Csikszentmihalyi, 1988). Another early criticism is that it was too ethereal, bordering on mystical, for it to be considered something worthy to be studied in the social sciences (Csikszentmihalyi, 1988). Also, the flow theory as discussed in Csikszentmihalyi's book, Flow - The Psychology of Optimal Experience, only gives indicators of the flow experience, but does not explicitly explain how to achieve this state.

2.13 Scope

The flow theory has made its way into many different disciplines from its early beginnings rooted in psychology. It has permeated sociology, education, advertising, work-related activities, cultural anthropology, religion, and most obviously in the context of play and leisure. Its contribution to psychology, especially internal motivation, has been profound, as well as the field of intrapersonal communication. It does not see how this theory relates directly to the context of mass media. Also, it was unable to find any references to any studies done in the field of interpersonal communication, but some scientists see this as a field where flow theory may also surface.

However, one heavy criticism of flow, relating to scope, is that it is too Western a psychic phenomenon (Sun, 1987) and it was more applicable to men than women (Csikszentmihalyi, 1988). Although, Csikszentmihalyi (1988) admits that the context of the flow experience varies from culture to culture, it is the dynamic of the flow experience that is universal. Han's research on Korean men and women, and a study on American working women by Wells (1985) have responded to this criticism (Csikszentmihalyi, 1988).

2.14 Anxiety in Sport

2.14.1 Definition and Measurement of Anxiety

Spielberger (1972) defined anxiety as an emotional reaction to a stimulus perceived as dangerous. This stimulus, or "stressor," results in dysphoric thoughts and feelings, unpleasant sensations, and physical changes. If a person does not find a stimulus threatening, then changes in anxiety should not result: the same stimulus may be perceived as a beneficial challenge to one individual, threatening to another, and neutral to a third. Means of assessing anxiety include observation of overt behavior, physiological indicators (e.g. heart rate, galvanic skin activity, stress hormones), and self-report (Hackfort & Schwenkmezger, 1989). Each approach has limitations. Assessments of behaviors indicating anxiety can be time consuming or even misleading: the behavior (e.g. pacing) may be unrelated to anxiety or may be a coping strategy that reduces anxiety. Commonly used physiological assessments of anxiety (e.g. heart rate) are sometimes unrelated to anxiety state and often invasive. Thus, anxiety is most commonly assessed through self-report. Self-report measures have been developed to assess both transitory and stable aspects of anxiety (Spielberger, 1972). Because psychological states can change dramatically in intensity from moment to moment, it is important to measure state anxiety or anxiety intensity at a given time (Spielberger et al., 1983). Trait anxiety refers to an individual's general tendency to experience elevations in state anxiety when exposed to stressors. Persons high in trait anxiety should experience greater increases in state anxiety when exposed to a stressor than those low in trait anxiety. In fact, athletes with higher levels of trait anxiety do exhibit greater increases in state anxiety before competition than low-trait-anxious athletes (Raglin & Turner, 1993; Hanin, 1980, 1986).

Although self-report measures provide advantages over most physiological assessments of anxiety, they also have limitations. The validity and reliability of self-report measures can be affected by verbal ability and the level of self-awareness

(Hackfort & Schwenkmezger, 1989). Responses may be distorted by social desirability, demand characteristics, and expectations (both social and experimental), any of which may invalidate self-reports. Repeated assessments of state anxiety, especially over a short time span, can result in habituation, or stereotypical responses. Finally, assessing anxiety prior to competition may be distracting or may actually alter responses by directing attention to emotional states (Hackfort & Schwenkmezger, 1993). Despite these problems, most researchers agree that appropriately used, validated self-report measures provide accurate assessments of anxiety. There is some disagreement as to whether measures specific to context (e.g. sport) or subtypes of anxiety components (e.g. somatic) are more accurate than general measures.

Arousal may be defined as a general physiological and psychological activation varying on a continuum from deep sleep to intense excitement (Gould & Krane, 1992). When we are bored, relaxed or asleep, we are in a state of low arousal. When excited, angry or anxious, we are in a state of high arousal. You can see from this that being in a state of high or low arousal is not in itself necessarily a pleasant or unpleasant experience. On the other hand, anxiety is by definition an unpleasant sensation. Weinberg & Gould (1995) have offered the following definition of anxiety, a negative emotional state with feelings of nervousness, worry and apprehension associated with activation or arousal of the body. We can thus think of anxiety as an unpleasant state of high arousal. The term stress has a broader meaning than anxiety. Stress is the process whereby an individual perceives a threat and responds with a series of psychological and physiological changes, including increased arousal and the experience of anxiety. We tend to experience stress when we meet demands that are difficult to meet, but which carry serious consequences if we fail to meet them. If stress is long-term, or chronic, it can cause serious harm to both physical and mental health. Whilst it is quite normal - and as we shall see quite beneficial - to experience some anxiety before competing, athletes should not feel constantly anxious and see themselves as facing insurmountable odds.

2.14.2 Social Physique Anxiety

Social physique anxiety is a personality disposition defined as “the degree to which people become anxious when others observe their physiques' (Hart et al., 1989). It reflects people’s tendency to become nervous or apprehensive when their bodies are evaluated (Eklund et al., 1991). People with high social physique anxiety, versus people without this kind of anxiety, report experiencing mote stress during limes: evaluations and experiencing more negative thoughts about their bodies. It has also been found that a nagative relationship exists between social physique anxiety and exercise behaviour and perceived physical ability (Hausenblas et al., 2004), and that social physique anxiety is related to need satisfaction, physical activity motivation, and behaviour (Brunet & Sabiston, 2009). People with high social physique anxiety, then, are likely to avoid fitness setting or struggle with motivation when they participate because they fear how others will evaluate their physiques An encouraging finding is that that physical activity interventions can reduce social physique anxiety in participants (Hausenblas et al., 2004). If you can reduce people's social physique anxiety by having them exercise in less revealing shorts and T-shirts, instead of right-fitting clothes, you can increase their participation in physical activity (Crawford & Eklund, 1994).

2.14.3 Connecting Arousal and Anxiety to Performance

One of the most compelling relationships that sport and exercise psychologists study is the relationship (positive or negative) between arousal, anxiety, and emotional states on the one hand and performance on the other. Most of us recognize readily enough when our nerves make its feel vulnerable and out of corn rot. But how exactly do physiological arousal and psychological arousal function to the advantage of one person and the detriment of another? How does it happen I hat even in our own per on a single afternoon, we can nonce fluctuations in anxiety level and their effects? Sport and exercise psychologists have studied the relation of anxiety and performance for decades. They haven't, reached definitive conclusions, but they have illuminated aspects of the process that have several implications for helping people psych up and perform better, rather than psyching out and performing poorly. Some 50 years ago, researchers concentrated on drive theory, which was later used in the 1960s and 1970s to explain social felicitation.

2.14.4 Anxiety Direction and Intensity

For many years, most researchers assumed that anxiety has only negative effects on performance. English sport psychologist Graham Jones and his colleagues (Jones et al., 1994; Jones, 1995), however, showed that an individual interpretation of anxiety symptoms is important for understanding the anxiety-performance relationship. People can view anxiety symptoms either as positive or helpful to performance (facilitative) or as negative and harmful to performance (debilitative). In fact, to fully under-stand the anxiety-performance relationship, you must examine both the intensity of a person's anxiety (how much anxiety the person feels) and its direction (his interpretation of that anxiety as facilitative or debilitative to performance). Jones and colleagues basically contended that viewing anxiety as facilitative leads to superior performance whereas viewing it as debilitative leads to poor performance. Jones (1995) also developed a model of how facilitative anxiety and debilitative anxiety come about. Specifically, some stressor occurs in the environment, such as running in the finals at the state track meet. How much stress a runner will experience depends on individual-difference factors such as her trait anxiety or self-esteem. Most important, whether the resulting state anxiety is perceived as facilitative or debilitative depends on how much control the athlete perceives. If the runner feels in control (e.g. that she can cope with the anxiety and that running a certain time in the race is possible), then facilitative anxiety will result. However, if she believes that there is no way she can run a competitive time and that she can't cope with the pressure, debilitative anxiety occurs. The athlete's perception of control relative to coping and goal attainment is critical, then, in determining whether state anxiety will be viewed as facilitative or debilitative. Sport psychologists have already found some support for this association between how anxiety is perceived and performance level. For example, good balance beam performances have been associated with gymnasts interpreting cognitive anxiety as facilitative (Jones et al., 1993). Similarly, elite swimmers have reported both cognitive and somatic anxiety as more facilitative and less debilitative than have non-elite swimmers (Jones & Swain, 1992). Most impressive was a series of two studies by Hanton & Jones (1999[a], 1999[b]). In the first study, 10 elite male swimmers who consistently maintained facilitative anxiety interpretations in competition were interviewed. Results revealed their parents, coaches, and more experienced swimmers all played a role in helping the swimmers learn to perceive anxiety as facilitative versus debilitative. The swimmers also developed goal-setting and imagery skills that helped them productively manage their anxiety. Thus, they developed cognitive skills and strategies over an extended period of time in hot h formal and informal ways, and these skills helped I hem view their competitive anxiety as facilitative. In study 2, three swimmers who consistently experienced debilitative anxiety learned goal setting, imagery, and self-talk skills identified in study I in an effort to change their anxiety from debilitative to facilitative. Results revealed that over 10 races, all three swimmers were able to switch their debilitative anxiety to facilitative and their performances improved. Thus, it has been shown that athletes can be taught to view anxiety as facilitative! Additional research by Wadey & Hanton (2008) has examined how use of the basic psychological skills of goal setting, self-talk, imagery, and relaxation is associated with the direction and intensity of elite athletes' anxiety. Findings revealed that these elite swimmers maintained the intensity of their anxiety leading up to competition and used goal setting, self-talk, and imagery to interpret their anxiety as facilitative. The results suggest that it may not always be appropriate to use relaxation techniques to lower anxiety intensity, but a repertoire of psychological skills should be taught to help athletes interpret anxiety symptoms as facilitative. In summary, how an athlete interprets the direction of anxiety (as facilitative or debilitative) has a significant effect on the anxiety-performance relationship. Athletes can also learn psychological skills that allow them to interpret their anxiety as facilitative. It follows that coaches should try to help athletes view increased arousal and anxiety as conditions of excitement instead of fear. Coaches should also do view increased arousal and anxiety as conditions of excitement instead of fear. Coaches should also do everything possible to help athletes develop perceptions of control through enhancing confidence and through psychological skills training.

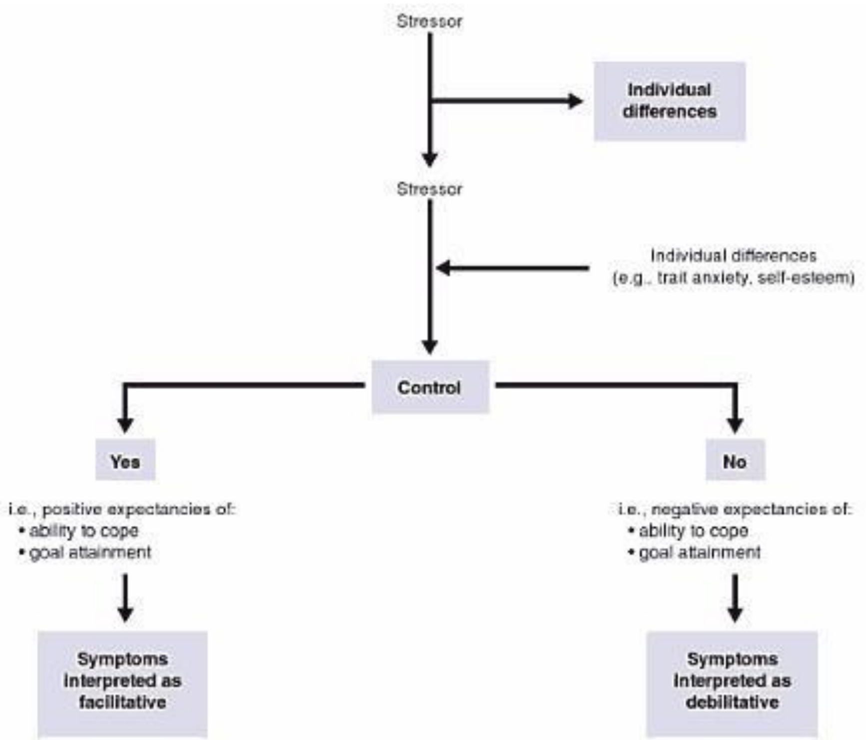

Fig. 9: Jones' model of facilitative and debilitative anxiety (adapted from Jones, 1995).

2.14.5 Multidimensional Anxiety Theory

Hanin's IZOF hypothesis did not address whether the components of state anxiety (somatic and cognitive anxiety) affect performance in the same way. These state anxiety components are generally thought to influence performance differentially: That is, physiological (somatic state anxiety) arousal and worry (cognitive state anxiety) affect performers differently. Your heart racing or pounding and your mind reiterating negative predictions, for instance, can affect you different tally. Multidimensional anxiety theory predicts that cognitive state anxiety (worry) is negatively related to performance. Thai is, increases in cognitive state anxiety lead to decreases in performance. But the theory predicts that somatic state anxiety (which is physiologically manifested) is related to performance in an inverted U. with increases in the anxiety facilitating performance up to an optimal level, beyond which additional anxiety causes performance to decline. Although studies have shown that these two anxiety components differentially predict performance, the precise predict ions of multidimensional anxiety theory have not been consistently supported (Hardy et al., 1996; Gould et al., 2002; Arent & Landers, 2003; Mellalieu et al., 2006). Consequently, multidimensional anxiety theory has little support with respect to its performance predictions and is of little use in guiding practice.

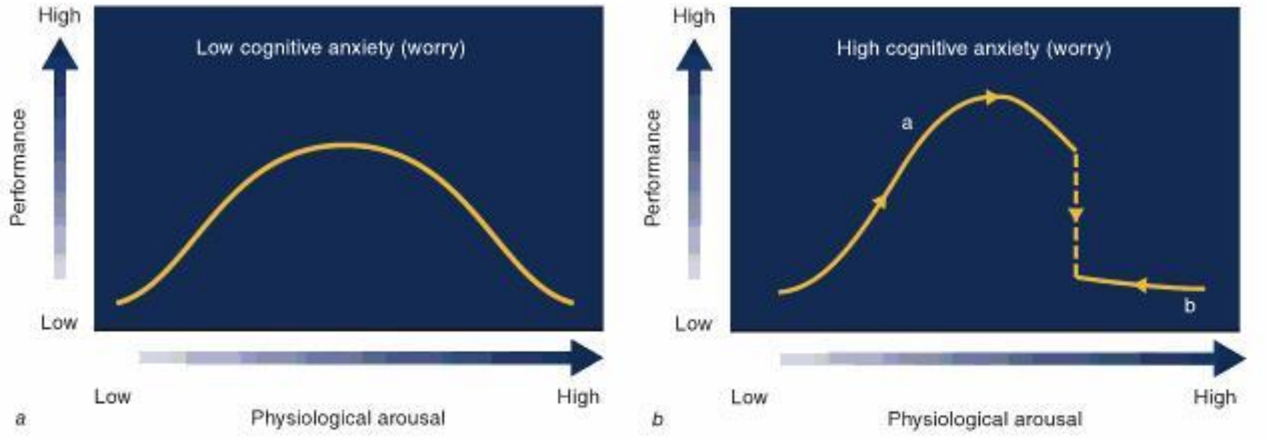

Fig. 10: Catastrophe theory predictions: (a) arousal-performance relationship under low cognitive state anxiety; (b) arousal-performance relationship under high cognitive state anxiety.

2.14.6 Explain how and why arousal- and anxiety-related emotions affect performance

Arousal-related emotions, such as cognitive and somatic state anxiety, arc related to performance. Arousal and anxiety influence performance by inducing changes in attention and concentration and by increasing muscle tension. Hanin's individualized zones of optimal functioning, Hardy's catastrophe model, Kerr's interpretation of reversal theory, and Jones' distinction between the direction and intensity of anxiety should guide practice. An optimal recipe of emotions is related to peak performance, and when performers are outside this optimal range, poor performance results. This optimal combination of emotions needed for peak performance does not necessarily occur at the midpoint of the arousal-state anxiety continuum, and the relationship between arousal and performance depends on the level of cognitive state anxiety (worry) a performer exhibits.

Anxiety can adversely affect sports performance in a number of ways. It is seen as a negative mental state that is the negative aspect of stress. In skills that require a great deal of concentration such as darts, golf putting and potting a ball in snooker or billiards, anxiety can potentially lead to lower performance levels due to reduced concentration and attention levels, and co-ordination faults. In gross motor skills, anxiety can have a negative effect on performance due to factors such as hyper-elevated muscle tension “freezing” and coordination faults. These negative effects of stress can lead to lower levels of performance, and as performance levels decrease further this can lead to a significant decrease in self-confidence. However, some of the symptoms of anxiety can also be beneficial for sports performance, such as increased blood flow, breathing rate and respiratory rate. These symptoms of anxiety are physiologically beneficial for performance, but if the athlete thinks that they are happening because of his or her inability to meet some form of demand, it is the perception of the athlete that will make these symptoms negative.

A great deal of research has been devoted to the effect of anxiety on sports performance. Researchers have found that competitive state anxiety is higher for amateur athletes in individual sports compared with athletes in team sports (Simon & Martens, 1977). In addition, participants in individual non-contact sports have been found to report lower levels of state anxiety than participants in individual contact sports (Lowe & McGrath, 1971). This section will review this research from the perspective of the theoretical models discussed above.

Cognitive anxiety has been found to exert a powerful influence on performance. This statement holds true regardless of the individual's skill level. Participants in a collegiate softball tournament were put into one of two conditions: high situation criticality or low. While somatic anxiety did not differ in the two situations, those athletes in the high criticality condition had significantly higher levels of cognitive-anxiety (Krane et al., 1994). Clearly the cognitive interpretation an individual gives to a situation exerts an effect. Researchers have found that athletes that are successful interpret arousal to be facilitative. Research conducted with an elite group of swimmers found that anxiety intensity levels were higher in subjects who interpreted their anxiety more debilitative than those who reported it as being facilitative (Jones et al., 1994). This has been found to be true of gymnasts (Jones et al., 1993) as well as basketball players (Swain & Jones, 1996). Gould et al. (1984) have reported that the strongest predictor of cognitive anxiety was years of experience such that the more experience an individual had the lower the level of cognitive anxiety. This was supported by research conducted with a group of tennis players. Advanced subjects (individuals who had been participating in the sport for an extended period of time) reported more facilitative interpretations of their anxiety than novices (Perry & Williams, 1998). Similar results have been observed among a group of elite swimmers (Jones et al., 1994). Perhaps this is due to previous experience with arousal and how to cope. This conclusion is supported by the research of Jones, Swain & Cale (1990) found that cognitive anxiety was best predicted by an evaluation of previous performances, individual's perception of preparedness, and goal setting.

The amount of self-confidence that an individual possesses has been found to differ among elite and novice athletes. Research with a group of tennis players indicated that the advanced players had significantly higher levels of self-confidence (Perry & Williams, 1998). This has been found to be true of gymnasts (Bejek & Hagyet, 1996) as well as swimmers (Jones et al., 1994). The predictors of self-confidence identified by research are perception of preparedness, and external conditions (Jones et al., 1990). Other researchers have found that the strongest predictor of self-confidence has been found to be the amount of ability that an individual believed he or she had (Gould et al., 1984). This makes sense given an individual's previous experience in a given situation. Self-confidence has been found to account for a greater proportion of variance in performance than cognitive or somatic anxiety (Hardy, 1996). This suggests that the most powerful quality that elite performers possess is a high level of self-confidence which may act as a protective factor from cognitive anxiety.

Although the research conducted focusing on cognitive anxiety and self-confidence provides some insight into their effect on athletic performance, the interaction of these variables in conjunction with somatic anxiety provides a better understanding of the true effects. Among a group of 91 athletes ranging in age from 14 - 36 years old who participated in soccer, swimming, and track and field, those individuals with higher scores on self-confidence and lower scores on cognitive anxiety and somatic anxiety perceived their overall anxiety levels as more facilitative of athletic performance (Wiggins & Brustad, 1996). Research conducted comparing athletes competing in team sports (basketball) with those competing in individual sports (track and field) has found that subjects competing in individual sports report significantly lower self-confidence and higher somatic anxiety than team sport athletes (Kirby & Liu, 1999). This is supported by research that has been conducted with figure skaters as well. Martin & Hall's (1997) research demonstrated that skaters experienced grater cognitive and somatic anxiety prior to an individual competitive event than prior to a team competition. Perhaps this is due to a diffusion of responsibility that occurs in the team framework but not in an individual framework. Important gender differences have also been found by researchers focusing on the relationship between cognitive anxiety, self-confidence, and somatic anxiety. Females had lower self-confidence and higher somatic anxiety scores than males on the CSAI-2 (Thuot et al., 1998). This research also focused on the location of an athletic event as well, finding that away games resulted in increased somatic anxiety and lower self-confidence. Finally, Thuot et al. (1998) found that adolescents, regardless of gender, experienced significantly higher levels of cognitive and somatic anxiety and lower levels of self-confidence as the ability of opponents increased. This is partially supported by research that has focused on the determinants of anxiety as well as gender. Among males, cognitive and somatic anxiety was more strongly affected by their perception of opponent's ability and probability of winning (Jones et al., 1991). Female's cognitive anxiety and self-confidence is determined by readiness to perform and the importance they personally placed on doing well (Jones et al., 1991). These gender differences are indicative of the need to develop interventions that are tailored to individual needs and the importance of considering all factors when developing an intervention.

Clearly, anxiety exerts a variety of effects on athletic performance. These effects vary based on sport, gender and level of experience. In order to facilitate peak performances by athletes, sport psychologists must consider the three different facts of anxiety: cognitive anxiety, somatic anxiety, and self-confidence. Given the research that indicates that successful athletes who interpret their anxiety as being facilitative is characterized by high scores on self-confidence and low scores on somatic and cognitive anxiety, sport psychologist should work towards achieving this ideal state among their clients. Let us now turn our attention to the variety of treatments that are available for the treatment of anxiety within the athletic context.

2.14.7 Assessment of Anxiety

In sport psychology research, a variety of approaches have been used to quantify anxiety, including the observation of overt behavior, biological activity (e.g. galvanic skin activity, heart rate, stress hormones), and self-reports. No single method is entirely reliable. Assessments of behaviors implicated in anxiety (e.g. pacing) may be an anxiety-reducing strategy for some individuals or may be entirely unrelated to anxiety in other instances. Physiological variables that have been used as biological correlates of anxiety (e.g. electromyogram EMG) may be difficult to assess prior to competition, or they may provoke an increase in anxiety in sonic cases (e.g. sampling blood to assess stress hormones). Because of these problems, anxiety is most commonly determined by means of self-report questionnaires. In sport research, the most frequently used general mea-sure of anxiety has been the State Trait Anxiety Inventory (STAI), a 40-item questionnaire that assesses both state and trait anxiety. Despite its proven validity, the efficacy of the STAI and other general measures of anxiety in the context of athletics has been questioned, leading to the creation of more than 30 sport-specific anxiety scales. Among these, the most widely used is the Competitive State Anxiety Inventory-2 (CSAI-2), a multidimensional anxiety measure that assesses self-confidence, somatic anxiety, and cognitive anxiety (Spielberger, 2004).

Despite advantages such as the ease of administration and interpretation, self-report measures are not without limitations. The validity and reliability of sell-reports are delimited by verbal ability and self-awareness of emotional slates. Administering questionnaires near the lime of competition can be impractical or disruptive and might even result in increased anxiety by directing attention to internal emotional states. A more serious problem is response distortion, which occurs when individuals respond falsely to questionnaires for reasons such as social desirability, the demand characteristics of the experiment, and personal expectations. Response distortion can be detected through the use of lie scales, but this form of control is rarely used in sport psychology research (Spielberger, 2004).

2.14.8 Traditional Theoretical Perspectives on the Anxiety-Performance Relationship

It has been a long-standing belief in sport psychology that high levels of anxiety experienced during competition are harmful for performance and. if unabated, may even result in some athletes quitting their sport. A variety of interventions have been employed by sport psychology practitioners to reduce anxiety, including hypnosis, progressive relaxation, visualization, biofeedback, autogenic training, meditation, negative thought stopping, and confidence enhancement. However, it also has been posited that anxiety can facilitate performance under particular conditions. This perspective originally stemmed from drive theory, otherwise known as Hullian theory. According to Hullian theory, performance is a function of drive (i.e. physiological arousal or anxiety) and habit strength (i.e. skill). High levels of anxiety should increase the likelihood of correct behavior for well-learned skills, as would be the case loran emotional pep talk presented to a group of talented athletes. Evidence for drive theory in sport settings is lacking, however, and the theory currently has little status in the field of sport psychology.

Theoretical- explanations in which high anxiety adversely influences performance have a higher standing in sport psychology, none more so than the Yerkes-Dodson law, familiarly known as the inverted-II hypothesis. The hypothesis stems from the classic work by Yerkes and Dodson, who in 1908 examined the influence of stimulus intensity on habit formation in experiments when mice were timed in maze running. Discrete levels of difficulty were created by manipulating the level of illumination of the maze and subjecting the mice to several intensities of stimulation via electrical shocks. The highest intensity shocks were found to slow learning under the most difficult (i.e. dimmest) maze trial, suggesting that moderate stimulation was best for such conditions. These results have since been widely reported in both general psychology and sport psychology textbooks, and they have been generalized to a number of constructs such as drive, motivation, learning, arousal, and anxiety. In sport psychology, the hypothesis is presented as a relationship between athletic performance and either arousal or, more commonly, anxiety. Optimal performance should occur when anxiety is within a moderate range of intensity, whereas deviations above or below this range should result in progressively worsened performance. Hence, anxiety and performance exhibit a relationship describing the shape of an inverted U. In basic terms, optimal performance is most likely to occur when anxiety is neither too high nor too low, hut because of the stressful nature of sport competition; it is assumed that it is far more likely for athletes to experience too much anxiety.

2.14.9 Sport Competition Anxiety Test

Competition creates some anxiety in nearly everyone, and intense anxiety keeps people from performing well or enjoying themselves. Individual differences in competitive anxiety are obvious, and many consultants spend considerable time helping participants learn to control anxiety. Much of that work sterns from Martens' (1977) competitive anxiety model and the Sport Competition Anxiety Test (SCAT), which set a model for sport-specific personality measures. Martens began with real-world observations and built upon existing psychological work:

1. Interaction approach Individual differences in competitive anxiety are easy to see, and situational factors also play a role. Close, important games create more anxiety than less important contests. Even the calmest athlete becomes anxious under some conditions. To understand competitive anxiety, we must consider the person, the situation, and the ongoing interactive process.

2. State-trait anxiety distinction. Spielberger (1966) distinguished the relatively stable personality characteristic of trait anxiety from the immediate, changeable feelings of state anxiety. Trait anxiety is the tendency to become anxious in stressful situations (a personality disposition). State anxiety is the actual state of apprehension and tension at any given moment (an emotional response). A high trait-anxious person might see an upcoming tennis match as a threat and respond with high state anxiety, whereas another might perceive it as a challenge and remain relatively calm.

3. General versus specific anxiety High trait-anxious people may not become equally anxious in all stressful situations. One person may become overly anxious in competitive sport but remain calm in academic exams. Another might never become anxiety in competition but panic in social settings. Psychology researchers had demonstrated that situation-specific measures of trait anxiety predict state anxiety more accurately than more general anxiety measures. Following that line of thought, Martens proposed the personality construct of competitive trait anxiety, defined as “a tendency to perceive competitive situations as threatening and to respond to these situations with feelings of apprehension or tension” (1977).

4. Competition process. The final step places competitive anxiety within the context of the competition process. The primary situational source of anxiety in competition is evaluation. We want to do well and we worry about performing poorly. But people do not worry to the same extent. Competitive trait anxiety affects our perceptions and

subsequent anxiety through the cognitive appraisal process that is central to all emotion.

Martens developed the SCAT to measure the sport-specific personality disposition of competitive trait anxiety. To determine your competitive anxiety, take the SCAT (appendix A). If you score high (above the 75th percentile), you probably tend to be quite nervous and tense in competition: if you have a low score, you probably control anxiety well and seldom choke in competition. The test items are simple and straightforward, but extensive psychometric testing indicates that those items best identify high- and low-anxious competitors. Details on the development of the SCAT with reliability and validity data are published elsewhere (Martens, 1917; Martens et al., 1990). In brief, the SCAT meets all generally accepted standards for psychological tests, and considerable research demonstrates that it predicts state anxiety in sport competition. The SCAT quickly became one of the few useful personality measures in sport and exercise psychology, and Martens' extensive research set a model that others have followed in developing sport-specific measures. The SCAT, a valuable research tool, also has practical value in identifying competitors who might benefit from training in anxiety management.

2.15 Hypotheses

- It is assumed that the neural activation of prefrontal cortex using Classification Number Test in comparison with Stimulus Response Test and the No-Intervention-Control-Condition under the Own Zone “hard” running on treadmill leads to low significant Flow by CNT between measurement duration points.
- It is assumed that the neural activation of prefrontal cortex using Classification Number Test in comparison with Stimulus Response Test and the No-Intervention-Control-Condition under the Own Zone “hard” running on treadmill leads to high significant Flow by CNT measured by female test persons after 20 min running.
- It’s assumed that the performance of CNT Index leads to high significant difference measured by whole test persons after 20 min running in Own Zone “hard” level in comparison with the setting position.

3 Experimentes and Methods

3.1 Experimentes

The sample (N = 33) consisted of 11 female and 22 male running experienced test persons, from it were students in the sport science and students from other studies fields. The average age of the women was 22.8 years (SD = 1.25), that one of the men amounted by 23 years (SD = 2.07). The test persons answered voluntarily on a public call which has been put up in different places of the university.

Experiment design

The investigation carried out in the training scientific laboratory of the institute for performance diagnostics and health promotion at the Martin-Luther University Halle-Wittenberg. The test subjects have to absolve a 30-minute running on treadmill. They should stay with it within a first of all defined person specific intensity area.

The determination of this personal heart rate target zone (OwnZone®) based on scientific knowledge to the behavior of the heart rate variability at rising load intensity (Tulppo et al., 1996; Laukkanen et al., 1998; Hottenrott, 2006).

At this treadmill investigation it is particular that the intensity of running was not determined by the adjusted velocity but the treadmill velocity was controlled according to the heart rate of the runner automatically. For this comes especially a programmed treadmill (Pulsar 30 of the company h/p cosmos) for use. The influencing of the velocity over the heart rate represents a stress oriented control. The area of OwnZone® was chosen "hard" approx. 80-90 % of the maximal heart rate to make sure that all runners are exposed to manageable demands above average.

PE-students (N = 33) had to run on a treadmill within three test specifications. In the first experimental-condition, prefrontal-dependent abilities were tested using a Classification-Number-Test. To ensure that the measured effect is not due to a distraction of attention, in control-condition two, the students had to perform a test of prefrontal-independent abilities (Stimulus Response Test). A third control-condition was realized without any additional tasks. Flow was measured using the Flow-Short-Scale (Rheinberg, 2003).

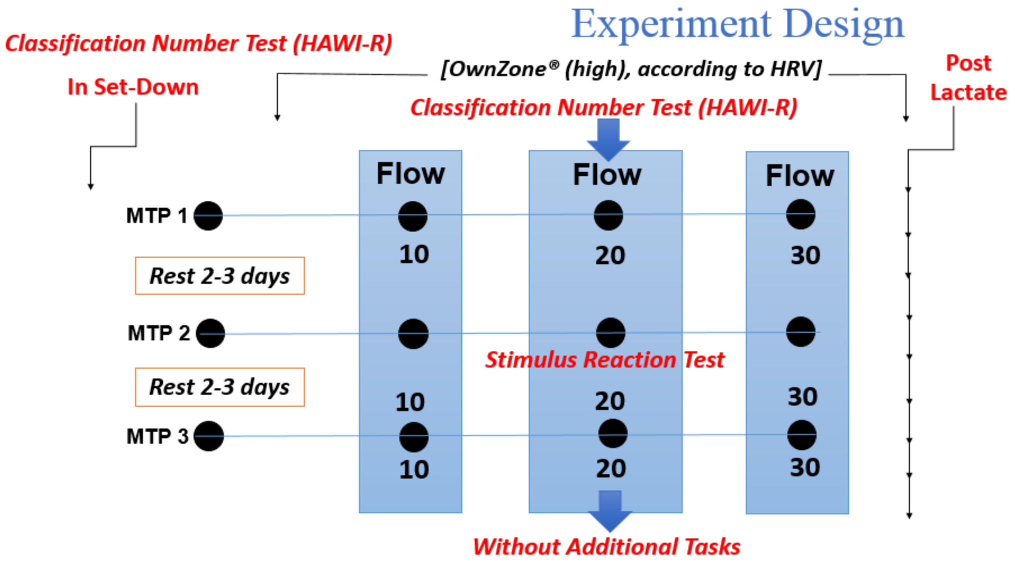

Fig. 11: The experimental design of the Flow-Experience in relation to the three test specifications (Classification-Number-Test, Without Additional Tasks and Stimulus-Response-Test).

Description of 30 min Treadmill running

First of all, the determination of the OwnZone® took place "hard" according to the use instructions for the heart rate measuring instrument HF of the heart rate equipment manufacturer Polar (Finland). After that the test person increased the movement intensity from the slow walking through the rapid walking up to running every minute. After an average of three minutes the OwnZone® “hard” was determined by the heart rate equipment manufacturer and a lower and upper limit value defined (e.g. 165 to 177 beats per minute).

A 15-minute break which served the recovery was accomplished after this short test. During this time the test person sat on a chair and received a short instruction in the experimental development and the Flow diagnostics.

Lactate, heart rate and heart rate variability determination

At first, the determination of rest lactate value, a first blood sample from this one with Finalgon®, taken from hyperemia earlobe. The diagonal belt serving for the heart rate measurement, which laid out. The first minute was run with 6 km/h to enable a preparation on the following load. Then the running velocity was regulated through the control program of the treadmill, that the test person runs always in the before defined heart rate area (OwnZone® "hard"). For this purpose, the control unit of the treadmill increases the velocity initially, until the target frequency is achieved. The use oriented regulation then started in the further course. During running the parameters velocity and heart rate were recorded permanently. After 10, 20, and 30 minutes the test persons interrupted for approx. a minute their running and were so available for the course diagnostics. Within these rest times was taken blood to determination of the lactate value, the Flow-Experience was registered.

Flow determination

For recording of Flow-Experience came the Flow-Short-Scale (FSS) of Rheinberg et al. (2003) for use. The FSS consists of altogether 16 items. The first 10 items show with a 7-Point-Likert-Scale ("not correct" = 1 until "correct" = 7) components of Flow-Experience and are summarized as a general factor (Flow-Total-Score). The general factor of the FSS has been subdivided into two factors (Sub-Dimensions) to the further differentiation of the Flow-Construct. Factor I contains six items, these statements concerning it without exception and describe "a smooth automated course" of an action.

Factor II contains four items which are in connection with "Absorption". This subdivision is to Rheinberg et al. (2003) meaningful, since there are differences in this from, how very much the Flow-Experience is appropriately reported from persons over the components "smooth course or "Absorption". The reliability coefficient of the 10 items in the general factor (Cronbach's Alpha) locates according to the information of Rheinberg (2003) in the area around a = 0.90. So that, it is not useful to expect that Flow exclusively arises to the demand situations, but can worry and anxiety also be aroused, the FSS was enlarged by an "Anxiety Component". This consists of three items (No. 11 to 13, Cronbachs a 0.80 to a = 0.90).

The test persons carried out three assessments to the Demand-Ability-Fit (on a 9 Points-Scale) at the end of the Flow-Short-Scale. The item 14 focuses there - on a comparison of the difficulty of the present activity with all other activities at (light vs.

heavy) and the item 15 on the own efficiency (low vs. high). The item 16 asks directly, on the current activity (here therefore the running on the treadmill) obtained, in terms of subjective observed Demand-Ability-Fit (very low vs. very high).

Descriptive and checked statistic

The statistical analysis was performed with SPSS 17.0., for descriptive Representation of the Mean (M) and Standard Deviations (SD) was calculated. In the present ordinal variables, the statistical test with nonparametric tests performed. Between independent groups (VG and KG) was the Mann-Whitney U-Test was applied for dependent samples was carried out using the Wilcoxon Test. The significance level was set at $p \leq 0.05$ (*) and und $p \leq 0.01$ (**).

Critical annotations to methodology

During the progression of the Stimulus-Response-Test, the students had to press directly on a computer keyboard, as they reacted to the signal which came from the monitor. A specific finger-equipment to press during running would be more practice and comfortable.

During the measuring of the Flow-Experience at OwnZone® "hard" on the treadmill, it came to unexpected discontinuance by two test persons, because they were not in the condition to continue their running with maximal intensity for long time. A reason for that case would be a miss contact between the heart rat instrument and the treadmill receiver, which leaded to this maximal intensity without to reach the relevant heart rate.

Sport acting of participants in performance-thematic situations (e.g. with a competition) does not have to be exclusively intrinsic motivated, so that success or failure estimate can affect the Flow experience (prize moneys, spectator, sponsors).

The action requirements can be subject situation in the process to strong fluctuations and depending upon maximum stress of the athlete more or less in the equilibrium with its current efficiency.

Except individual achievement parameters (e.g. running time, placement o.a.) field studies do not supply information over the psycho physical condition of the athletes, so that one can rely only on the subjective AFP estimates.

This methodological criticism at the field studies suggested the conception of the laboratory study. Goal was it, apart from the answer of the central question whether the AFP on these controlled demand conditions for the runners is a condition for the occurrence of Flow to examine also the dynamics of the Flow experience in the time progression and in dependence of physiological performance parameters when running under specific laboratory conditions.

One could assume hypothetically a training-scientific parameter, how the OwnZone®, which is according to Polar an objectively optimal zone of the individual Demand-Ability-Fit, is noticed evenly also subjectively as optimal and thus running in this zone can induce Flow experience in accordance with the conceptions of Csikszentmihalyi (1975).

Results

4.1 Statistical analysis of study parameters depending on test measurement points

Study Parameters of male and female test persons

Flow of Classification Number Test (Flow^{CNT})

Flow of Classification Number Test was determined from questionnaire values measured using Flow Short Scale (FSS, Rheinberg et al., 2002) during the running on the treadmill every 10 min 3x times for individual test persons ($n^{1,2}$ = 33; n^{3} = 26). Running to Flow^{CNT} resulted in significantly greater estimated Flow values in measuring points 1 and 3 when compared with measuring point 2 due to the treatment of the Classification Number Test (see Fig. 12 and Tab. 2).

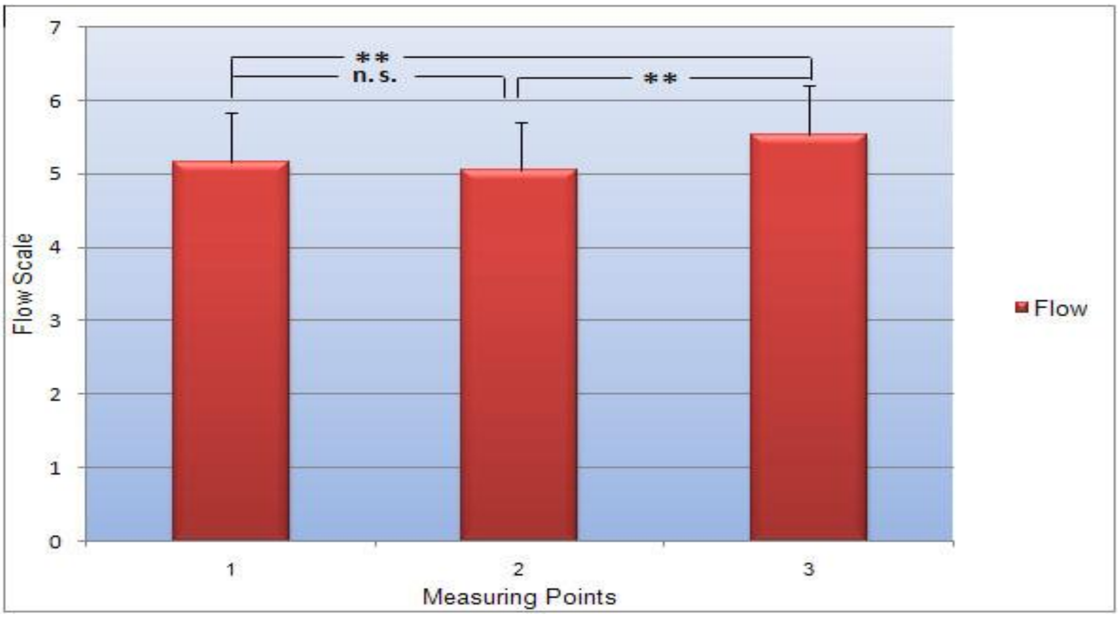

Fig. 12: Mean Flow of Classification Number Test (Flow^{CNT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) of test persons (n = 33). (** significance level p ≤ 0.01).

Flow of Stimulus Response Test (Flow^{SRT})

Following running for 20 min (measurement point 2) at individually OwnZone ***"hard"*** after the treatment with the Stimulus Response Test, although the estimated Flow values within the FSS was not significantly different from values estimated for measurement point 3, there were significantly greater Flow values within the FSS compared with the measuring point 1 (see Fig. 13 and Tab. 2).

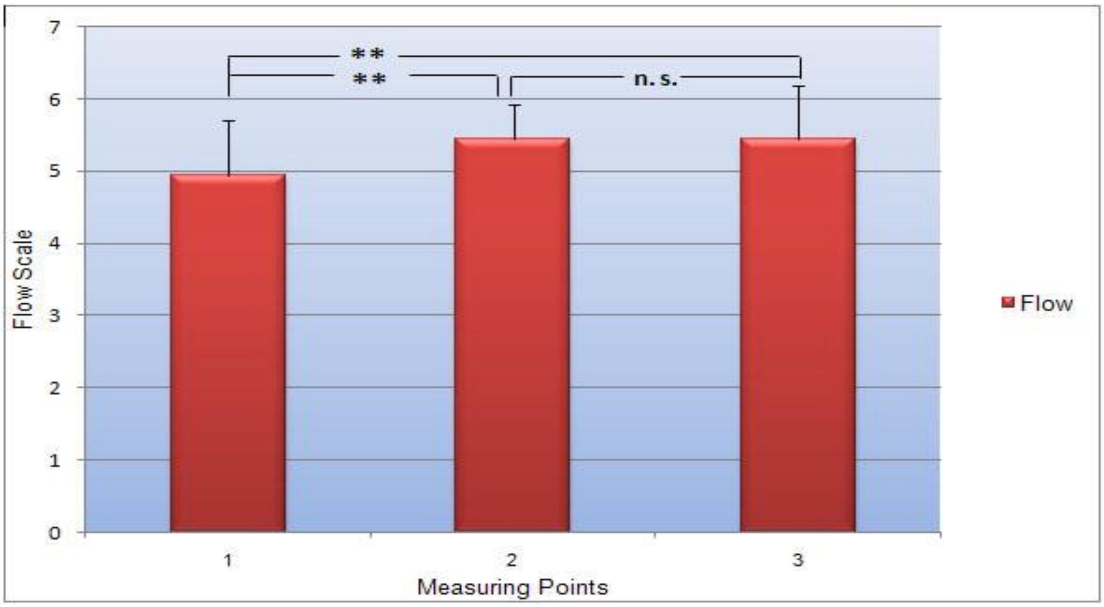

Fig. 13: Mean Flow of Stimulus Response Test (Flow^{SRT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) of test persons (n = 33). (** significance level $p \leq 0.01$).

Flow Without Additional Tasks (Flow^{WAT})

Running at individually OwnZone ***"hard"*** for 20 min Without Additional Tasks resulted in a significantly greater Flow values than measurement point 1 after 10 min. No detectable difference was observed between measuring points 2 and 3 following running at the same intensity running level on the treadmill (see Fig. 14 and Tab. 2).

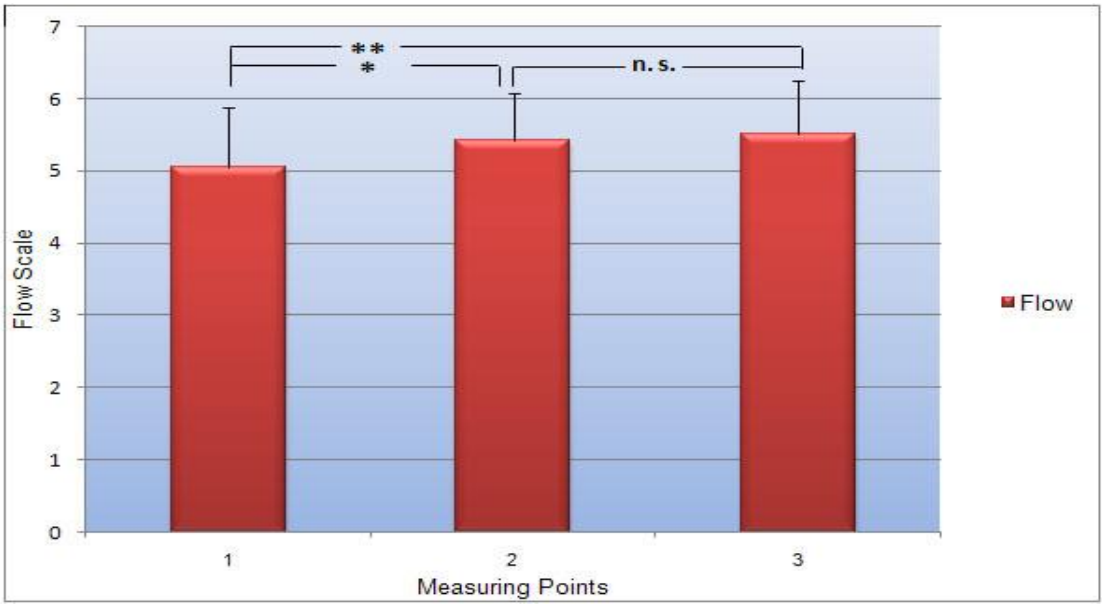

Fig. 14: Mean Flow Without Additional Tasks (Flow^{WAT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) of test persons (n = 26). (** and * significance level $p \leq 0.01$ and $p \leq 0.05$).

Tab. 2: Flow significance between subjects (measuring points 10, 20 and 30 min) in every single test (CNT, SRT and WAT)

Parameter	Classification Number Test			Significance
	Measuring Point 10 min	Measuring Point 20 min	Measuring Point 30 min	
Flow^{CNTa}	5,15 ± 0,69	5,05 ± 0,65		0,36
Flow^{CNTb}	5,15 ± 0,69		5,52 ± 0,68	**0,003****
Flow^{CNTc}		5,05 ± 0,65	5,52 ± 0,68	**0,00****
Parameter	**Stimulus Response Test**			**Significance**
Flow^{SRTa}	4,95 ± 0,75	5,44 ± 0,49		**0,00****
Flow^{SRTb}	4,95 ± 0,75		5,44 ± 0,75	**0,00****
Flow^{SRTc}		5,44 ± 0,49	5,44 ± 0,75	0,98
Parameter	**Without Additional Tasks**			**Significance**
Flow^{WATa}	5,05 ± 0,83	5,42 ± 0,65		**0,02***
Flow^{WATb}	5,05 ± 0,83		5,51 ± 0,73	**0,01****
Flow^{WATc}		5,42 ± 0,65	5,51 ± 0,73	0,27

4.2 Statistical analysis of study parameters depending on groups measurement points

Study Parameters of male and female test persons

After 10 min Test Measurement Points (Flow^{CNT}, Flow^{SRT} and Flow^{WAT})

Throw Fig. 15 and Tab. 3 started the mean comparison between the groups. The general trend across all measuring points 1, 2 and 3 for (Flow^{CNT}, Flow^{RRT} and Flow$^{WAT)}$ wasn't a significantly greater in any measuring point after the first 10 min running on the treadmill.

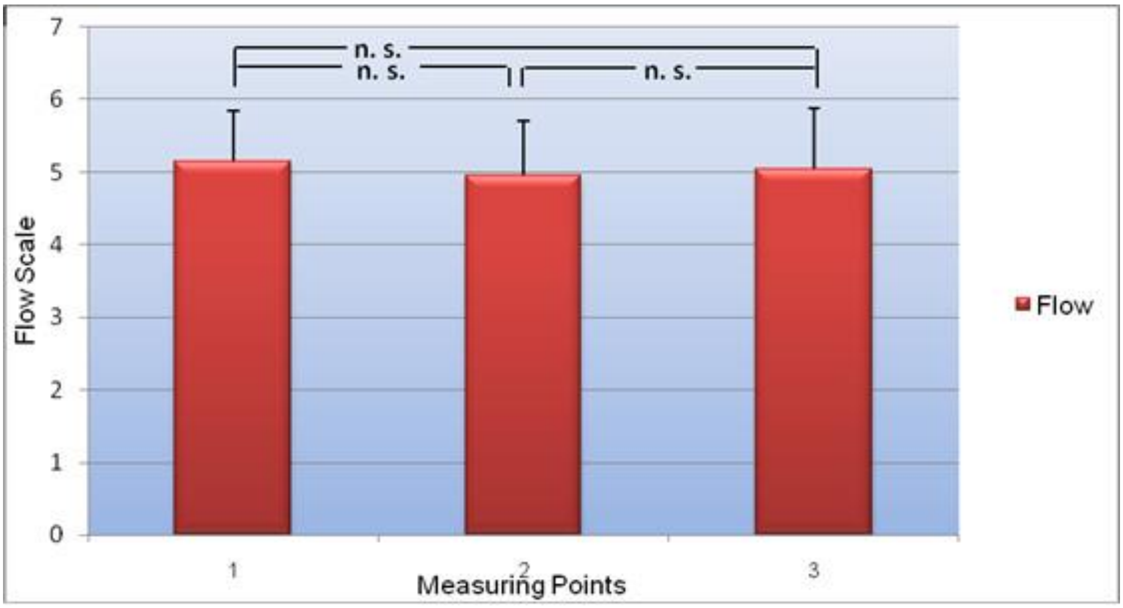

Fig. 15: Mean Flow^{CNT}, Flow^{SRT} and Flow^{WAT} in measuring points 1, 2 and 3 (questionnaire after 10 min) of test persons ($n^{1,2}$ = 33 and n^{3} = 26). (not significant $p \leq 0.05$).

After 20 min Test Measurement Points (Flow^{CNT}, Flow^{SRT} and Flow^{WAT})

Fig. 16 and Tab. 3 indicated absolutely the most important result of the study, which supported the "***Transient Hypofrontality Hypothesis***" that exercise decreases neural activity in the prefrontal cortex. There were significantly less Flow values after the treatment with the stimulated Classification Number Test after running 20 min on the treadmill in individual calculated OwnZone® **"hard"** level. No difference was detected between the Flow values following running in the measuring points 2 and 3 (SRT and WAT) when all mean validated Flow values were taken into account.

As comparisons, it will be mentioned in Fig. 7 and Fig. 10 to (a) possible difference between the male and the female test persons in the estimated Flow values after the treatment with Classification Number Test and (b) changes of Classification Number

Test Index between the male and the female test persons during the running on the treadmill.

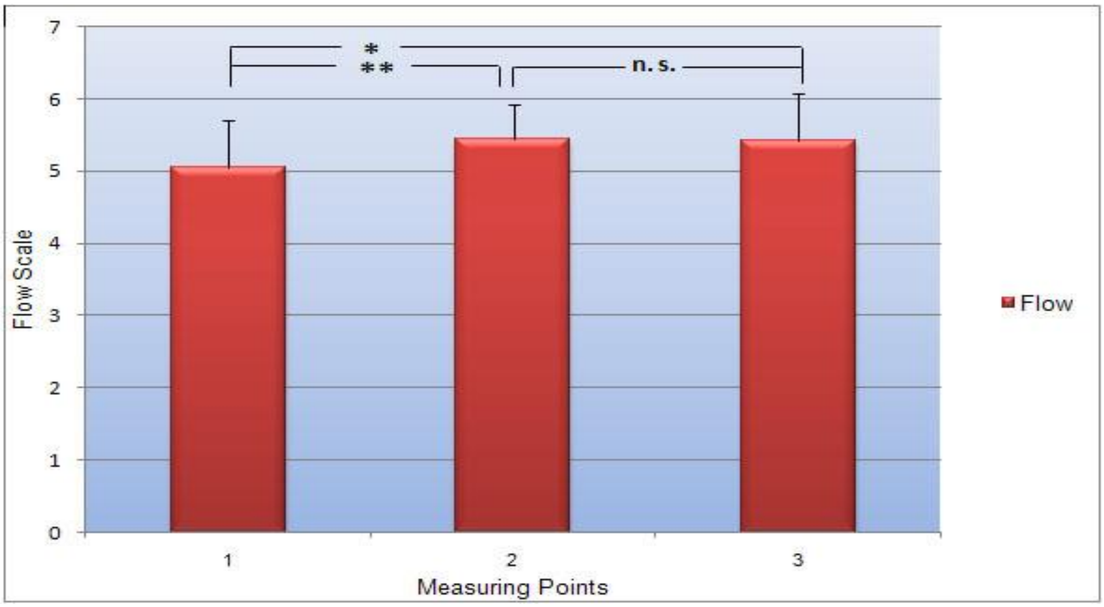

Fig.16: Mean $Flow^{CNT}$, $Flow^{SRT}$ and $Flow^{WAT}$ in measuring points 1, 2 and 3 (questionnaire after 20 min) of test persons ($n^{1,2} = 33$ and $n^{3} = 26$). (** and * significance level $p \leq 0.01$ and $p \leq 0.05$).

After 30 min Test Measurement Points ($Flow^{CNT}$, $Flow^{SRT}$ and $Flow^{WAT}$)

As the same results in Fig. 16, the mean estimated Flow values after 30 min running between the groups wasn't significantly higher in any measuring points 1, 2 and 3 for ($Flow^{CNT}$, $Flow^{SRT}$ and $Flow^{WAT}$). However, there was a strong effect, showed in Fig. 5 due to the stimulation of prefrontal cortex in light of the Classification Number Test (see Fig. 17 and Tab. 3).

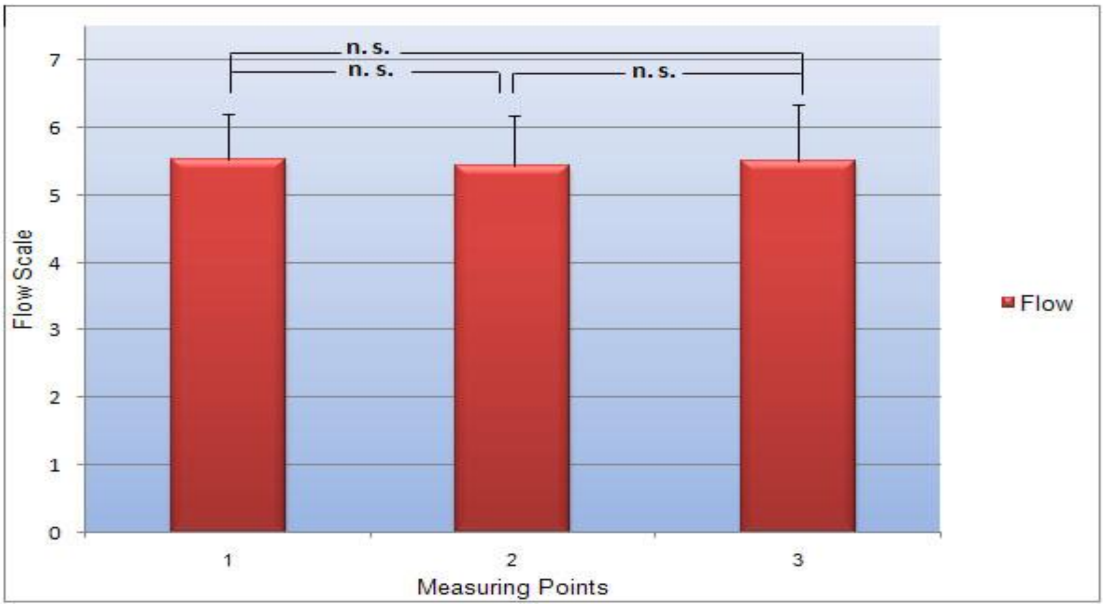

Fig.17: Mean $Flow^{CNT}$, $Flow^{SRT}$ and $Flow^{WAT}$ in measuring points 1, 2 and 3 (questionnaire after 30 min) of test persons ($n^{1,2} = 33$ and $n^3 = 26$). (not significant $p \leq 0.05$).

Tab. 3: Flow significance between groups (Test: CNT, SRT and WAT) in measuring points 10, 20 and 30 min

Parameter	Tests of Study			Significance
	CNT	SRT	WAT	
Flow[a]	5,15 ± 0,69	4,95 ± 0,75		0,18
Flow[a]	5,15 ± 0,69		5,05 ± 0,83	0,37
Flow[a]		4,95 ± 0,75	5,05 ± 0,83	0,79
Parameter	**CNT**	**SRT**	**WAT**	**Significance**
Flow[b]	5,05 ± 0,65	5,44 ± 0,49		**0,01****
Flow[b]	5,05 ± 0,65		5,42 ± 0,65	**0,02***
Flow[b]		5,44 ± 0,49	5,42 ± 0,65	0,71
Parameter	**CNT**	**SRT**	**WAT**	**Significance**
Flow[c]	5,52 ± 0,68	5,44 ± 0,75		0,49
Flow[c]	5,52 ± 0,68		5,51 ± 0,73	0,92
Flow[c]		5,44 ± 0,75	5,51 ± 0,73	0,64

CNT: Classification Number Test **SRT**: Stimulus Response Test **WAT**: Without Additional Tasks

Flow[a]: Flow by 10 min **Flow[b]**: Flow by 20 min **Flow[c]**: Flow by 30 min

4.3 Statistical analysis of study parameters between male and female test persons

Study Parameters of male and female test persons

Flow of Classification Number Test (Flow^{CNT})

The aim of the present study is to investigate and comparison the possible differences between the male and the female test persons among all measurement duration points. In the Flow^{CNT} data, the * indicates that $p \leq 0.05$, so mean Flow experience by the female test persons is significantly higher than the males after the Classification Number Test. As a control factor it will be referred in Fig. 23 to the mean Post Lactate to determine the possible changes of the lactate concentrations between the male and the female test persons after the running (see Fig. 18 and Tab. 4).

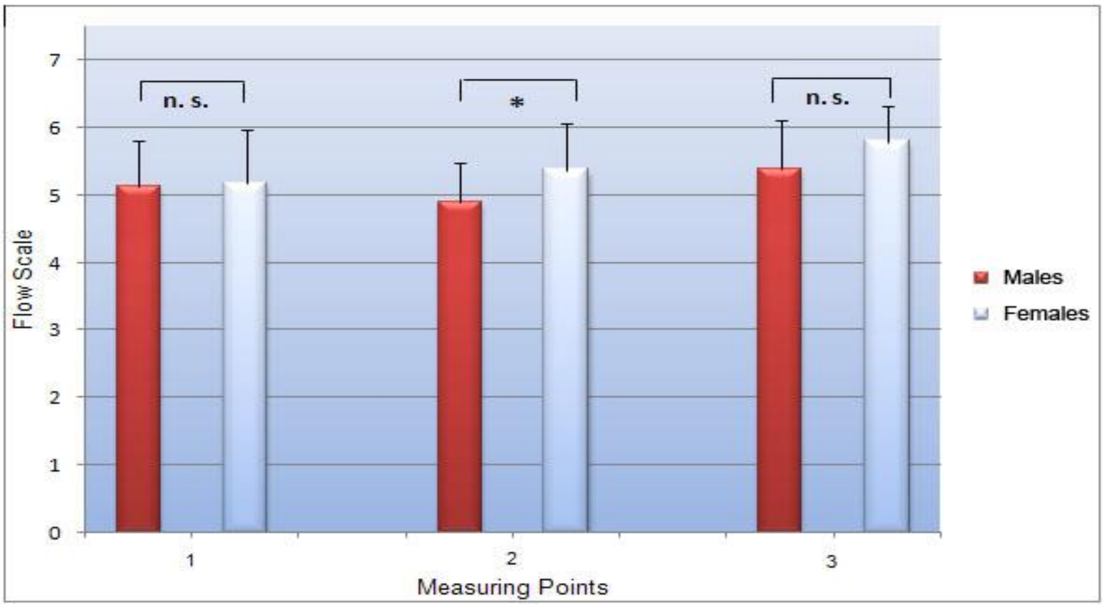

Fig. 18: Mean Flow of Classification Number Test (Flow^{CNT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) between male and female test persons (n = 33; M = 22 and F = 11). (* significance level $p \leq 0.05$).

Flow of Stimulus Response Test (Flow^{SRT})

The Flow^{SRT} data in Fig. 19 and Tab. 4 supplied no significant difference between males and females according to the treatment with the Stimulus Response Test after 20 min running at OwnZone ***"hard"*** level.

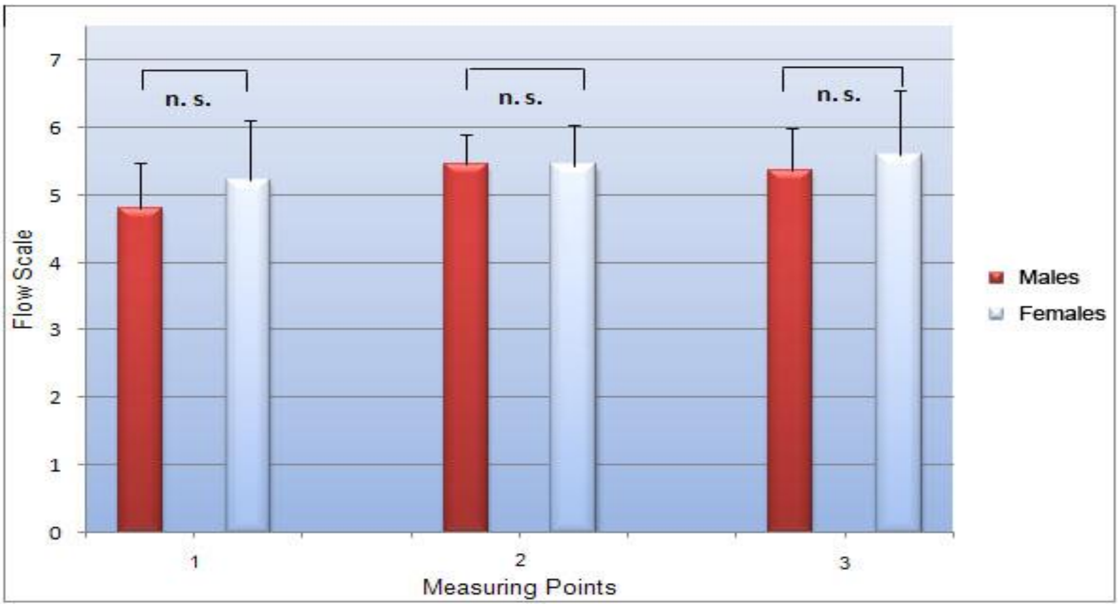

Fig. 19: Mean Flow of Stimulus Response Test (Flow^{SRT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) between male and female test persons (n = 33; M = 22 and F = 11). (not significant $p \leq 0.05$).

Flow Without Additional Tasks (Flow^{WAT})

Differences in Flow values by the answering of the FSS questionnaire were measured during the running on the treadmill in 10, 20 and 30 min on the contrary from the other two tests (CNT and RRT) between males and females Without Additional Tasks (WAT). In this state, there wasn't significantly higher in any measuring point (see Fig. 20 and Tab. 4).

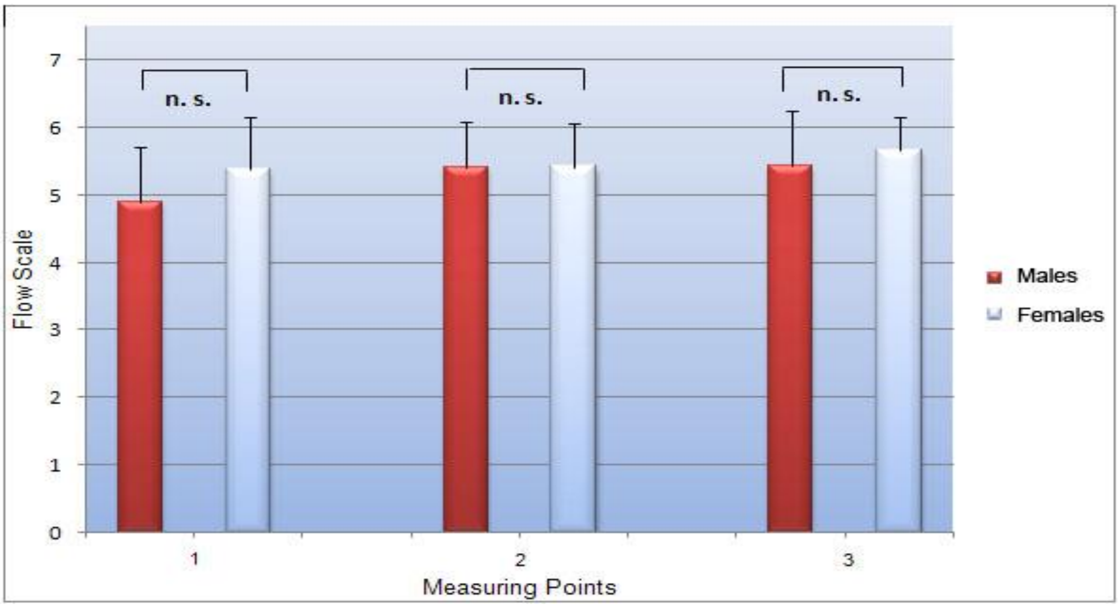

Fig. 20: Mean Flow Without Additional Tasks (Flow^{WAT}) in measuring points 1, 2 and 3 (questionnaire every 10 min) between male and female test persons (n = 26; M = 18 and F = 8). (not significant p ≤ 0.05).

Tab. 4: Flow significance between male and female test persons for every single test in measuring points 1, 2 and 3

Test persons (n = 33)	Classification Number Test		Significance
	Males (n = 22) M ± SD	Females (n = 11) M ± SD	
Flow^{CNTa}	5,14 ± 0,66	5,17 ± 0,80	0,890
Flow^{CNTb}	4,90 ± 0,57	5,37 ± 0,70	**0,044***
Flow^{CNTc}	5,39 ± 0,72	5,79 ± 0,54	0,110
Test persons (n = 33)	**Stimulus Response Test**		**Significance**
Flow^{SRTa}	4,81 ± 0,66	5,23 ± 0,87	0,132
Flow^{SRTb}	5,45 ± 0,44	5,43 ± 0,61	0,923
Flow^{SRTc}	5,36 ± 0,63	5,59 ± 0,97	0,412
Test persons (n = 26)	**Without Additional Tasks (M = 18; F = 8)**		**Significance**
Flow^{WATa}	4,89 ± 0,83	5,39 ± 0,76	0,165
Flow^{WATb}	5,42 ± 0,66	5,41 ± 0,65	0,973
Flow^{WATc}	5,44 ± 0,82	5,66 ± 0,50	0,495

4.4 Statistical analysis of study parameters between male and female test persons depending on position (Setting and Running)

Study Parameters of male and female test persons

Classification Number Test Index (CNT^{Index})

Comparison of the CNT^{Index} between the male and female test persons indicated that there were no noticeable changes in setting as well as on running but the females showed quite higher value in setting state than males (see Fig. 21 and Tab. 5).

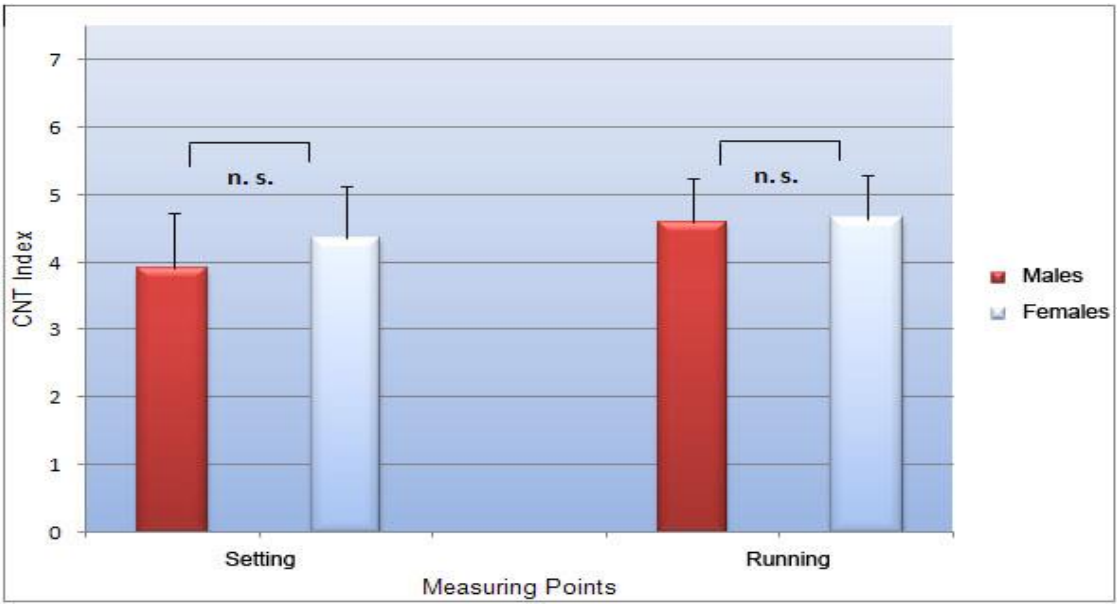

Fig. 21: Mean Classification Number Test Index (CNT^{Index}) in measuring points (Setting and Running, questionnaire during Running after 20 min) between male and female test persons (n = 33; M = 22 and F = 11). (not significant $p \leq 0.05$).

Tab. 5: Significance of Classification Number Test Index between male and female test persons in setting and running state

Test persons (n = 33)	Classification Number Test Index		Significance
	Males (n = 22) M ± SD	Females (n = 11) M ± SD	
In Setting	3,91 ± 1,11	4,36 ± 1,03	0,26
On running	4,59 ± 0,91	4,64 ± 0,93	0,89

4.5 Statistical analysis of study parameters depending on position (Setting and Running)

Study Parameters of male and female test persons

Classification Number Test Index (CNT^Index)

There was a high significant difference in setting and running state, the ** high significance of running $p \leq 0.01$ versus setting. It seems that on running can athlete more positive and effective thinking even when that related to mathematical solutions as it has shown in Fig. 22 and Tab. 6).

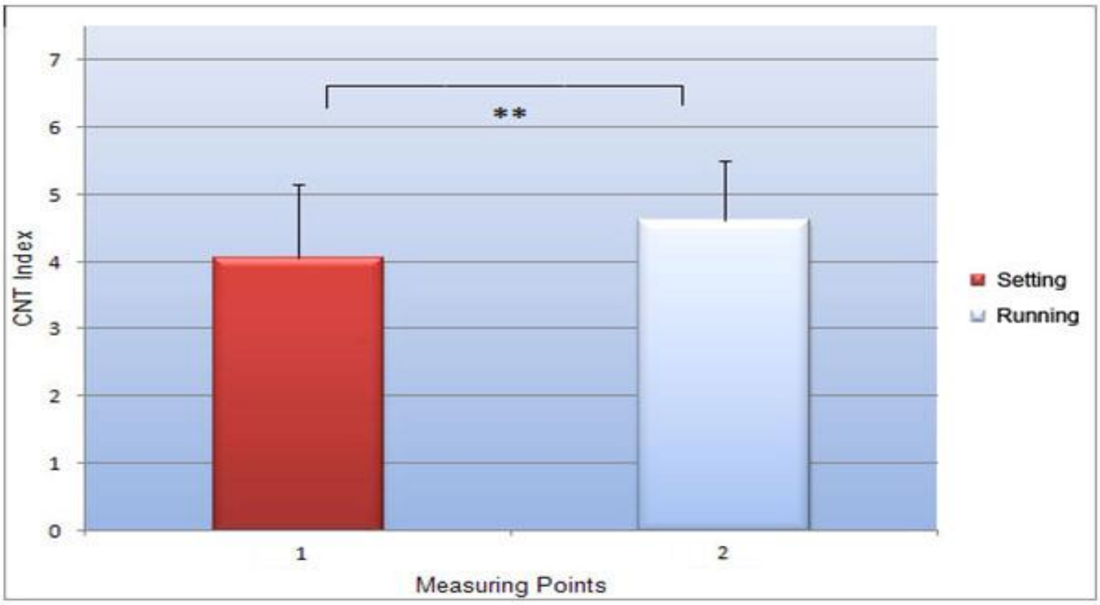

Fig. 22: Mean Classification Number Test Index (CNT^Index) in measuring points 1 and 2 (Setting and Running, questionnaire during Running after 20 min) for the test persons (n = 33; M = 22 and F = 11). (** significance level $p \leq 0.01$).

Tab. 6: Significance of Classification Number Test Index for the total test persons in setting and running state

Test persons (n = 33)	Classification Number Test Index		Significance
	Setting M ± SD	Running M ± SD	
CNT^Index	4,06 ± 1,09	4,61 ± 0,90	**0,00****

4.6 Statistical analysis of study parameters between male and female depending on post lactate concentration

Study Parameters of male and female test persons

Post Lactate Concentration (La^{Post})

Changes in lactate concentration at the end of the running give a predictive indicator if the intensity was significantly higher for male or female test persons. Indeed, there was no significant difference in all measuring points' tests. By the male athletes was the Post Lactate quite higher than this estimated by the females (see Fig. 23 and Tab. 7).

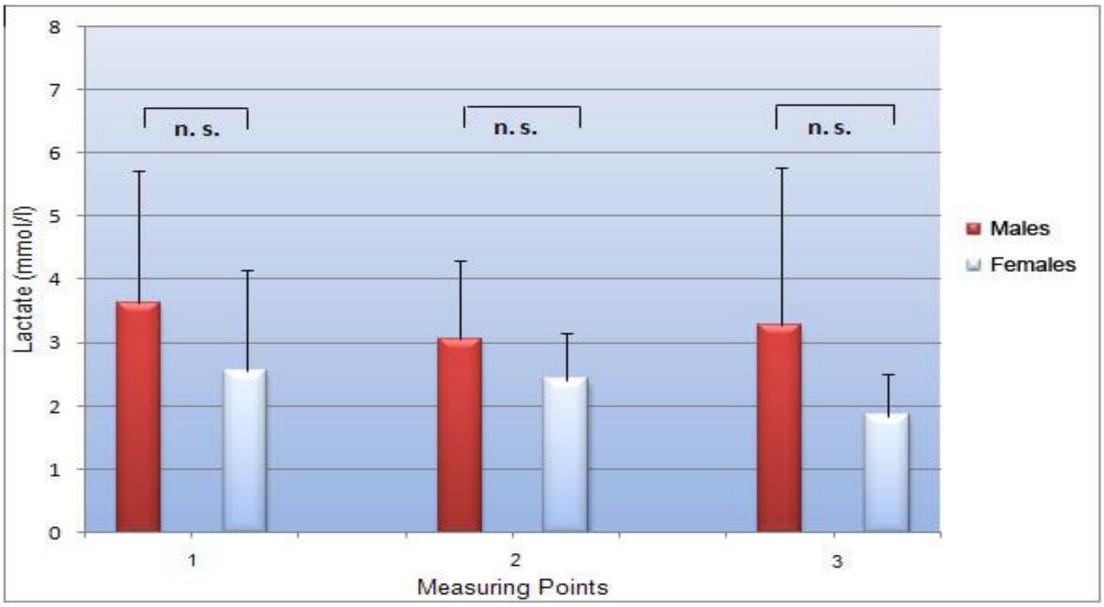

Fig. 23: Mean Post Lactate Concentration (La^{Post}) in measuring points 1 (CNT), 2 (SRT) and 3 (WAT) between male and female test persons ($n^{1,2}$ = 33 and n^{3} = 26). (not significant $p \leq 0.05$).

Tab. 7: Significance of Post Lactate Concentration between male and female test persons in every single test condition (CNT, SRT and WAT)

Test persons (n = 33)	**Classification Number Test**		**Significance**
	Males (n = 22) M ± SD	**Females (n = 11) M ± SD**	
La^{Post}	3,62 ± 2,11	2,55 ± 1,59	0,149
Test persons (n = 33)	**Reiz Reaction Test**		**Significance**
La^{Post}	3,06 ± 1,23	2,41 ± 0,75	0,120
Test persons (n = 26)	**Without Additional Tasks (M = 18; F = 8)**		**Significance**
La^{Post}	3,28 ± 2,49	1,84 ± 0,67	0,123

4.7 Statistical analysis of study parameters depending on post lactate concentration

Study Parameters of male and female test persons

Post Lactate Concentration (La^{Post})

At the same manner, reflected (Fig. 24 and Tab. 8) no significant changes in Post Lactate Concentration for the total test persons in measuring points 1, 2 and 3 (CNT, SRT and WAT). So it seems that the running intensity on the treadmill in all test the same was. Otherwise, as a control factor, supplies the figure important evedince that the changed in the flow experience could be explained due to the treatment with the various stimulations durinning running based on the Classification Number Test or the Reiz Reaction Test.

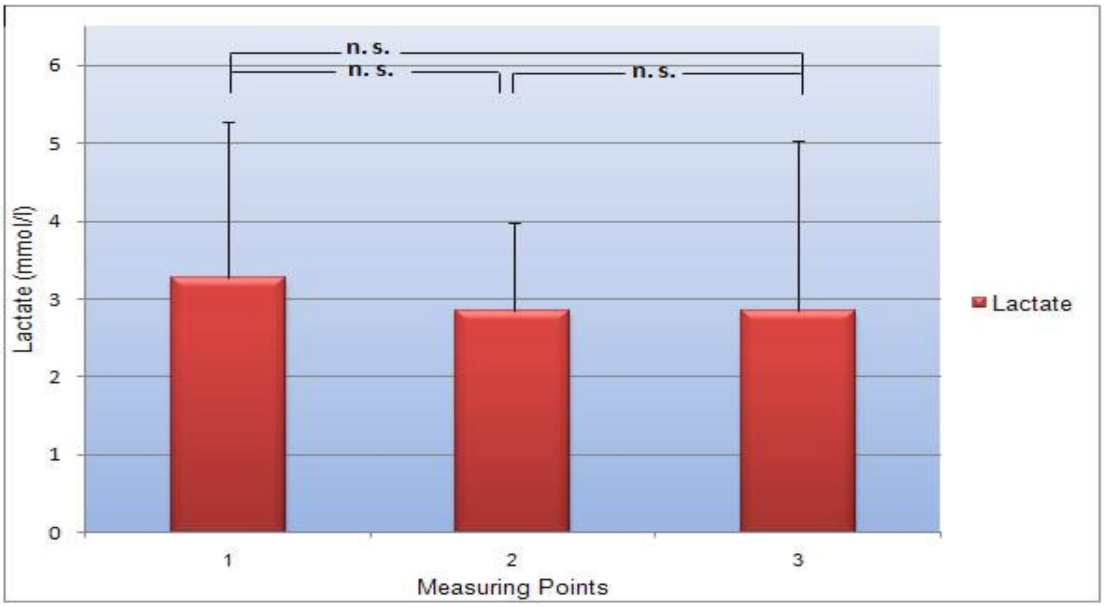

Fig. 24: Mean Post Lactate Concentration (La^{Post}) in measuring points 1 (CNT), 2 (RRT) and 3 (WAT) for the test persons ($n^{1,2}$ = 33 and n^{3} = 26). (not significant $p \leq 0.05$).

Tab. 8: Significance of Post Lactate for the total test persons in measuring points 1, 2 and 3 (CNT, RRT and WAT)

$n^{1,2}$ = 33; n^{3} = 26	Tests of Study			Significance
	CNT	SRT	WAT	
La^{Post}	3,27 ± 2,00	2,85 ± 1,13		0,28
La^{Post}	3,27 ± 2,00		2,84 ± 2,19	0,27
La^{Post}		2,85 ± 1,13	2,84 ± 2,19	0,92

4.8 Statistical analysis of study parameters depending on Anxiety Scale

Study Parameters of male and female test persons

Anxiety Scales of (AS^{CNT}, AS^{SRT} and AS^{WAT})

Respectively the Fig. 14-16 and Tab. 8, it wasn't found to be significantly higher compared to any measuring point in every single test. There was no significant difference between CNT, SRT or WAT. As on exception in the Stimulus Response Test (Fig. 25 and Tab. 9), it was significantly higher between measuring points 1 and 3 in the 10 and 30 min duration.

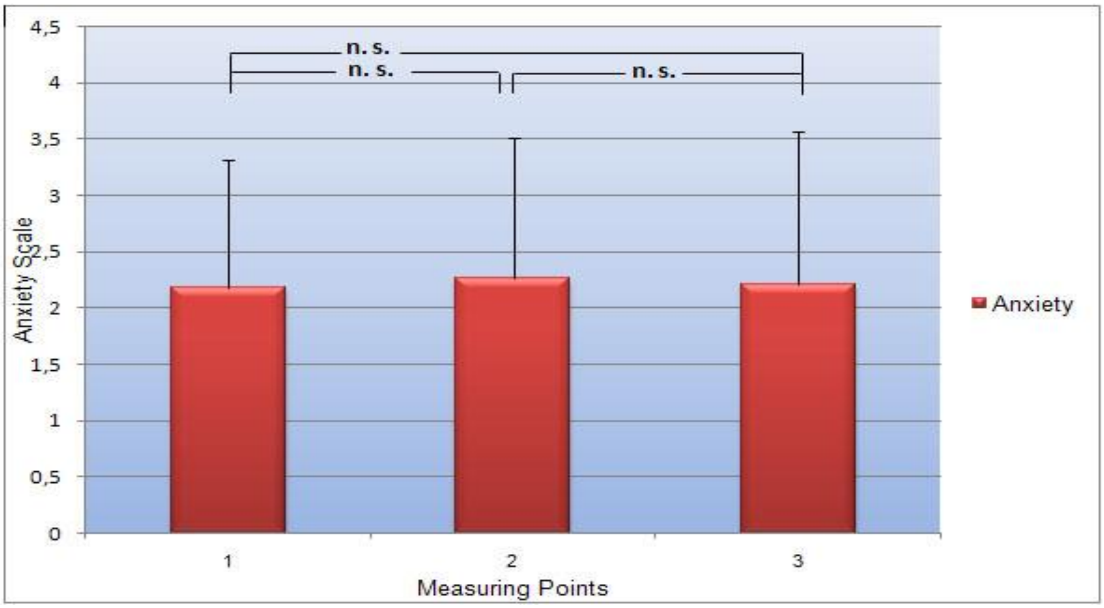

Fig. 25: Mean Anxiety Scale of Classification Number Test (AS^{CNT}) in measuring points 1, 2 and 3 for the test persons ($n^{1,2} = 33$ and $n^{3} = 26$). (not significant $p \leq 0.05$).

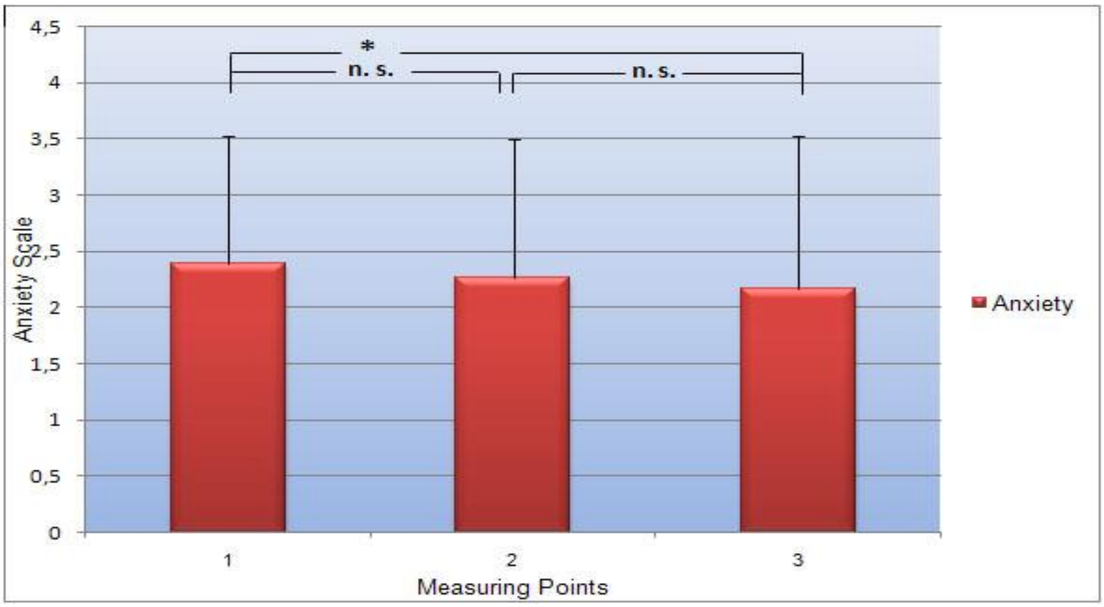

Fig. 26: Mean Anxiety Scale of Stimulus Responce Test (AS^{SRT}) in measuring points 1, 2 and 3 for the test persons ($n^{1,2} = 33$ and $n^3 = 26$). (* significance level $p \leq 0.05$).

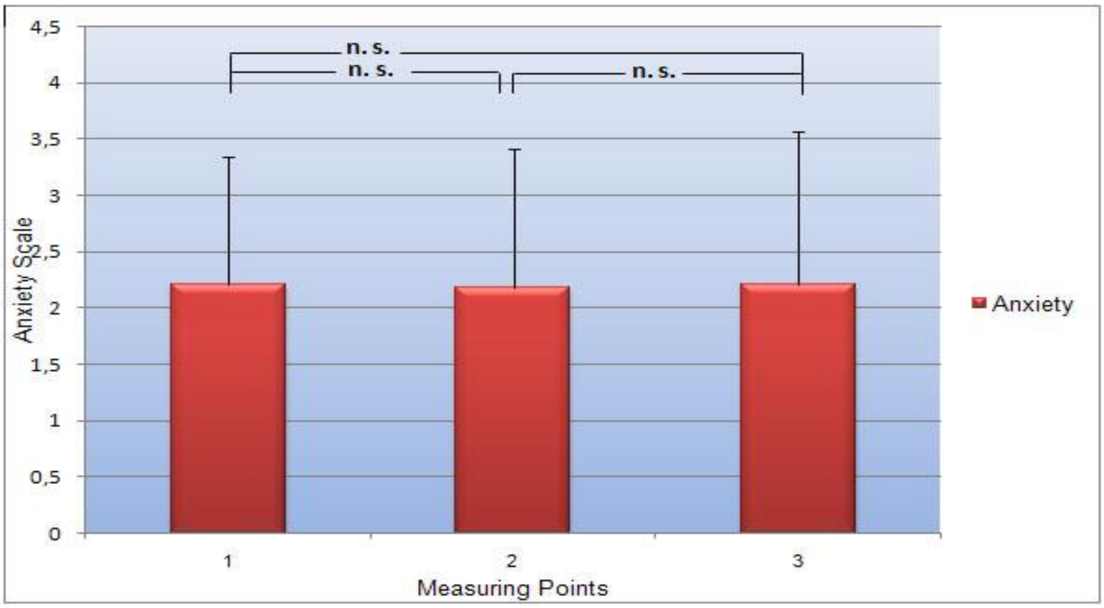

Fig. 27: Mean Anxiety Scale Without Additional Tasks (AS^{WAT}) in measuring points 1, 2 and 3 for the test persons ($n^{1,2} = 33$ and $n^3 = 26$). (* significance level $p \leq 0.05$).

Tab. 9: Significance of Anxiety in every single test in measuring points 1, 2 and 3 (after 10, 20 and 30 min)

n = 33	**Classification Number Test**			**Significance**
	10 min	**20 min**	**30 min**	
Anx[a]	2,18 ± 1,14	2,27 ± 1,24		0,43
Anx[a]	2,18 ± 1,14		2,21 ± 1,36	0,83
Anx[a]		2,27 ± 1,24	2,21 ± 1,36	0,56
n = 33	**Stimulus Response Test**			**Significance**
Anx[b]	2,39 ± 1,19	2,26 ± 1,17		0,26
Anx[b]	2,39 ± 1,19		2,16 ± 1,14	**0,05***
Anx[b]		2,26 ± 1,17	2,16 ± 1,14	0,07
n = 26	**Without Additional Tasks**			**Significance**
Anx[c]	2,21 ± 1,33	2,18 ± 1,36		0,76
Anx[c]	2,21 ± 1,33		2,21 ± 1,42	1,00
Anx[c]		2,18 ± 1,36	2,21 ± 1,42	0,84

5 Discussion

5.1 Preliminary Remarks

Flow experiences occur when we engage in activities that are intrinsically motivated and refer to a positive, activity-associated, subjective experience under conditions of a perceived fit between skills and task demands (Csikszentmihalyi, 1975; Furlong, 1976).

Flow is theoretically described as an optimal mental state (Csikszentmihalyi, 1990), and therefore flow is expected to be associated with optimal athletic performance as well as providing an optimal human experience (Jackson et al., 2001). Accordingly, in the sport psychology literature flow has generally been associated with peak performance states (e.g. Jackson et al., 1998; Jackson & Roberts, 1992). In the sport of golf, flow experiences have been strongly associated with peak performances (Cohn, 1991; Cately & Duda, 1997). Despite this initial evidence, Jackson et al. (2001) observed that “more research is needed to empirically examine the relationship between flow and performance in sport”.

To date, there have been few published studies examining the influence of psychological skills training programs on flow and performance. Notable exceptions include the work of Pates and colleagues, who have examined the effects of hypnosis on flow states and sporting performance (Pates & Maynard, 2000; Pates et al., 2001; Pates et al., 2002).

It is suggested that a necessary prerequisite to the flow phenomena is a state of transient hypofrontality that enables the temporary suppression of the analytical and meta-conscious capacities of the explicit system. Examining sensory-motor integration skills that seem to typify flow such as athletic performance (Dietrich, 2004, 2006).

According to Csikszentmihalyi (1996), any activity, mental or physical, can produce flow as long as it is a challenging task that demands intense concentration and commitment, contains clear goals, provides immediate feedback, and is perfectly matched to the person’s skill level. The cerebral cortex, and in particular the prefrontal cortex, is at the top of that hierarchy, representing the neural basis of higher cognitive functions (Frith & Dolan, 1996; Fuster, 2000).

However, the fact that people report automatic processing during flow and feel they operate without conscious thinking suggests that the prefrontal cortex is not required for the successful execution of these tasks. Recent advances in cognitive neuroscience have begun to identify the brain circuits underlying the explicit system. Evidence that the working memory buffer of the DLPFC holds the current content of consciousness, coupled with evidence that the executive attentional network of the DLPFC is the mechanism to select the content, suggests that the explicit system is critically dependent on prefrontal regions (Dehaene & Naccache, 2001; Ashby & Casale, 2002; Dietrich, 2003).

The analysis of neural correlates helps to focus the discussion of the flexibility/efficiency tradeoff between the explicit and implicit system on its significance to highly skilled human performance, a critical issue for understanding the effortlessness that characterizes the flow experience. Neuroimaging studies have shown that skill acquisition activates the prefrontal cortex, the premotor cortex, the parietal cortex as well as the cerebellum (Jenkins et al., 1994). Brain mapping studies using dynamic imaging methods demonstrate areas where regional cerebal blood flow (rCBF) decrease, as well as areas where flow increases, during performance of various experimental tasks. Thus, the patterns of CBF decreases during cognitive activity may reflect the attentional mechanisms that allocate processing resources during task performance (Haxby et al., 1994; Drevets et al., 1995[a,b]; Kawashima et al., 1995).

The implicit system cannot label the information itself as knowledge and thus cannot broadcast it to the system, preventing its use by other parts within that system. Only through the circuitous route involving actual behavior can the explicit system come to embody an implicitly learned skill. This is exemplified when trying to retrieve a phone number that is temporarily inaccessible. It is the central proposal of this paper that optimal performance involving a real-time sensorimotor integration task is associated with maximal implicitness of the tasks execution. Given that the explicit system is sub served by prefrontal regions, it follows from this proposal that a flow experience must occur during a state of transient hypofrontality that can bring about the inhibition of the explicit system. It is a commonly reported experience by athletes, such as golf players, that intense focusing can lead to smoother and more accurate performance. In addition, it has been reported that this effort is associated with decreased brain activation in cortical regions (Ross et al., 2003). In contrast, simply letting attention drift induces daydreaming (Singer, 1978; Dietrich, 2003), not flow.

The brain has to make due with a finite amount of metabolic resources. As a consequence, we possess a limited information processing capacity, which is not only true at the bottleneck of consciousness (Broadbent, 1958; Cowan, 1995), but it must also apply to unconscious, parallel information processing. This notion builds on the fundamental principle that processing in the brain is competitive (Miller & Cohen, 2001). Because sensorimotor integration tasks require massive and sustained activation of sensory, motor, and autonomic systems (Vissing et al., 1996; Ide & Secher, 2000), an individual may need to inhibit neural activity in regions performing functions that the individual can afford to disengage. These regions are, first and foremost, the higher cognitive centers of the prefrontal cortex, and thus the explicit system (Dietrich, 2003; Dietrich & Sparling, 2004).

The present study occupies with the comparison from altogether 33 male/female test persons, who finished successfully 30 min running on the treadmill at the Own Zone “hard” level under three test conditions “Classification-Number-Test (CNT), Stimulus-Response-Test (SRT), and Without-Additional-Tasks (WAT); No-Intervention-Control-Condition. The study is above all to evaluate the flow experience by means of specific pedagogic-physiological and psychological instruments. Thereby, it is went out from transient hypofrontality and flow hypothesis that it impossible to maintain the excessive neural activity in the PFC that is characteristic of the neural profile of depression, anxiety and stress. Thus, the flow experience will be interrupted (Dietrich, 2003).

5.2 Interpretation of the Results

- It is assumed that the neural activation of prefrontal cortex using Classification Number Test in comparison with Stimulus Response Test and the No-Intervention-Control-Condition under the Own Zone “hard” running on treadmill leads to low significant Flow by CNT between measurement duration points.

This is the first study the researcher is aware of that has examined flow experiences using the Flow-Short-Scale across gender and under laboratory conditions during running “hard OwnZone®” according to heart rate variability in rest and setting position as potential independent variables to the flow experience and that has combined the qualitative lactate, anxiety measurements and quantitative assessment of flow.

Results from experiment with Classification Number Test, as a tool to activate the prefrontal cortex region of brain during the running on the treadmill with intensity of Own Zone “hard” showed stability of flow experience performing in 20 min, measured by Flow-Short-Scale (Rheinberg, 2003) in comparing to the 30 min measuring point at the same test method. In addition, the results showed significantly decrease of flow experience performing value with Classification Number Test (CNT) in 20 min, measured with Flow-Short-Scale (Rheinberg, 2003) in comparing to the 20 min measuring points with Stimulus Response Test (SRT) and the experiment Without Additional Tasks (WAT).

In explaining predispositions to experience flow, Csikzentmihalyi (1990) argued that particular activities that are more likely to produce flow, traits that assist in producing flow, and that there is a link between peak performance and peak experience (McInnman & Grove, 1991). Specifically, Csikzentmihalyi (1975) indicated that a skill-challenge balance was an essential precursor flow occurrence, and that flow was dependent upon the individual's ability to structure their consciousness so as to make flow possible. The complexities in examining flow relate to the concerns over qualitative and quantitative research approaches (Jackson & Marsh, 1996), yet the ability to effectively incorporate these approaches to the study of flow may have implications for applied sport psychology consultants. By identifying the psychological factors that enhance, inhibit, and disrupt flow, consultants and coaches may be better able to help athletes achieve optimal performance (Kimiecik & Stein, 1992).

Jackson (1992) provided information from in-depth interviews with elite figure skaters about specific factors related to flow occurrence. These skaters indicated that flow was facilitated by positive mental attitude, positive pre-competitive and competitive affect, maintaining appropriate focus, physical readiness, and partner unity. Factors perceived to prevent or disrupt flow were physical problems/mistakes, inability to maintain focus, negative mental attitude, and lack of audience response. Jackson (1995) later examined athletes' responses to questions about what facilitated, prevented, and disrupted flow in 28 elite athletes from seven different sports. Results of interview responses revealed 10 dimensions and included salient factors such as physical and mental preparation, confidence, focus, how performance felt, and optimal motivation, and arousal. In addition, 79% of the athletes surveyed felt that factors facilitating or preventing flow were perceived as controllable.

Jackson (1996) recently investigated athletes responses and found correspondence between dimensions of flow described by Csikzentmihalyi (1990) and athletes descriptions of their flow experiences. Through qualitative analysis of athletes interviews, those dimensions of flow represented most across the group's data were the autotelic experience of flow, total concentration on the task at hand, merging of action and awareness, and the paradox of control (Jackson, 1996). The autotelic dimension of flow has been defined as an intrinsically motivating participation in an activity for its own sake and is an aggregate of all other flow dimensions (Jackson, 1996). One consistent finding has been that when the activity was perceived as enjoyable, athletes described their state of mind in similar terms (Jackson & Csiksentmihalyi, 1999).

Jackson et al. (1998) recently examined psychological correlates within trait and state flow. Results provided support for the construct of flow in that similar sets of predictor variables explained significant relationships with flow at both the subscale and global level. Specific predictors were perceived ability, anxiety, concentration disruption, anxiety-worry and intrinsic motivation to experience stimulation. Support for construct validity of flow scales was also demonstrated in that the flow trait challenge-skill balance was most highly correlated with the trait measure of perceived ability, and the authors concluded that high perceived ability is crucial to facilitating flow states (Kimiecik et al., 1998). It may be that less-skilled athletes are less likely to experience flow because both their actual and perceived level of skill are lower than elite athletes.

In an effort to quantitatively study flow, the Flow State Scale (FSS; Jackson & Marsh, 1996) was developed. The nine FSS scales of the 36-item instrument represent Csikzentmihalhi's (1990) nine dimensions of flow and each dimension is measured by four items. The approach in developing the FSS was to establish construct validity of an inventory designed to measure flow as a hypothetical construct. Confirmatory factor analysis supported the nine scales and a hierarchical model in which one global flow factor explained correlations between the nine FSS factors. Internal consistency estimates for the FSS scales were satisfactory (alpha M = .83). The usefulness of a single global score compared to the set of nine FSS scores was not determined. In addition, it was proposed that future research use the FSS in determining various group differences (Jackson & Marsh, 1996).

Conceptual and methodological issues related to flow research have been noted (Kimiecik & Stein, 1992). Conceptual concerns such the nature of flow and how it occurs have been addressed in qualitative analyses of the flow concept (Jackson, 1995, 1996), yet other personal and situational variables such as gender and sport setting remain largely unexamined in their relationship with flow occurrence. Use of the FSS may help to clarify the qualitative relationships and complex construct of this concept.

The richness of the flow construct necessitates that measures are inclusive and incorporate both qualitative and quantitative approaches. Several dimensions of flow have been theoretically discussed and supported by research (Jackson, 1995, 1996; Jackson & Marsh, 1996; Jackson et al., 1998). In addition, sport and exercise psychology research has recognized the need for multidimensional and sport-specific measurements (Vealey, 1986; Gill et al., 1988). Therefore, in order for researchers to assess flow in a more systematic fashion, it is necessary to incorporate quantitative assessment of this construct into investigation that may delineate systematic relationships between potential antecedents of flow.

The main purpose of the study of Jackson et al. (2001) was to examine psychological factors of potential relevance to athletic flow experiences. Another investigation was designed to assess the psychometric properties of the Flow State Scale (FSS) in sports using confirmatory factor analysis (Stavroua & Zervasb, 2004).

Russell (2001) presented in his study the factors that disrupting flow experience. This study examined qualitative and quantitative aspects of flow within a group of college-age athletes. Six dimensions were formed to represent factors that disrupt an athlete once in flow state. Results are presented with the 13 higher order and 46 raw themes from which they were developed. A reliability check gave 94% agreement and the raw theme level and 100% at the higher order level. One raw data theme was discussed and changed to a different higher-order theme suggested by the checker.

Non-Optimal Environmental and Situational Influences. This dimension had the most responses and consisted of 40% of all athletes and 37% of all raw data themes. The higher order themes included in this dimension were; mechanical failure, negative feedback from coach, negative refereeing decision, what opponents are doing, stoppage in play, and environmental distraction. Mechanical failure was relevant for a triathlete (bicycle), and swimming (goggles). Negative coach feedback was pertinent to team athletes distracted directly by the coach's feedback, or discrepancies between their evaluation and the coach's evaluation of performance. One basketball player felt that referees disrupted flow "My game gets thrown off when the referees start making bad calls and as a result I start missing baskets." In addition, several athletes specifically indicated that opponents were capable of disrupting flow. Runners were concerned about opponents' pace, while football players were concerned with either opponent's hard or illegal hits. Three football players and one wrestler remarked that stoppages in play had an effect on disrupting flow, which was related to disruptions in concentration.

Performance Errors. Twenty-one percent of the athletes cited performance errors as disrupting flow, which accounted for 19.6% of all raw themes. All responses fit into one higher order theme by the same title. Of the nine athletes who cited a theme within this dimension, such occurrences as falls (track), turnovers and missed third down conversions (football), missed moves (wrestling) and trying to do too much in performance (baseball) represented various performance errors.

Inappropriate Focus. In addition to preventing flow, inappropriate focus was mentioned by 21% of the athletes as disrupting flow and accounted for 19.6% of all raw data themes. The two higher order themes that made up this dimension were loss of focus and performance related worry. Inappropriate focus took the form of simple loss of concentration during the event, to having one's focus become occupied on the game outcome. Excessive worry was also related to inappropriate focus, as indicated by a volleyball player "I think a close scoring game makes me feel pressured and I start worrying about what the coach is thinking and that I can’t screw up."

Non-Optimal Physical State. This dimension involving 17% of the athletes and comprising 15.2% of all raw data themes, included one higher order theme by the same title. The factors expressed within this theme included disruptive effects of flow from physical injury, pain during performance, and feelings of fatigue.

Putting Self-Pressure and Self-Doubt. Two athletes (5% of the sample) expressed disruptions of flow within this dimension (4.3% of all raw themes). Specifically, one baseball player felt his batting performance declined when he imposed increasing self-pressure and another volleyball player felt disrupted when she began to “second-guess” her performance.

Problems with Team Performance. Two athletes mentioned factors within this dimension which accounted for 4.3% of all raw themes and had a higher order theme of the same title. Responses within this dimension related to disruptions due to teammates performance and when there was the perception those teammates were not serious.

Briefly, a cornerstone of cognitive psychology is the concept that the brain has a limited information processing capacity (Broadbent, 1958) and is continuously balancing costs and benefits associated with efficient information processing (Pinker, 1999). Yet, global cerebral blood flow to the brain during exercise, as well as global metabolism and oxygen uptake, is constant (Ide & Secher, 2000).

Building on the fundamental principle that processing in the brain is competitive (Miller & Cohen, 2001) coupled with the fact that there are no additional metabolic resources available during exercise (Ide & Secher, 2000), the massive and sustained activation of motor and sensory systems during exercise (Vissing et al., 1996) must come at the expense of activity in other neural structures. The transient hypofrontality hypothesis suggests that this results in the temporary inhibition of brain regions that are not essential to performing the exercise, such as areas of the frontal lobe involved in higher-cognitive functions. Despite considerable physiological evidence in favor of the hypothesis (Dietrich, 2003), it is not clear how these data correlate with psychological function, particularly cognitive processes supported by the prefrontal cortex such as working memory, sustained and directed Attention, response inhibition, and temporal integration.

To understand the mechanism of flow experience and the psychological demands we need to link it with the human physiology and the neuroscience in sports. Neural activity in exercising non-human animals show that these neural regions represent but a small percentage of total brain mass, confirming that physical exercise requires massive neural activation in a large number of neural structures across the entire brain. It follows that prolonged, aerobic exercise would require the sustained activation of such a large amount of neural tissue. Despite such marked regional increases, global blood flow to the brain during exercise, as well as global cerebral metabolism and oxygen uptake, remains constant (Sokoloff, 1992; Ide & Secher, 2000). During exercise, the percentage of total cardiac output to the brain is drastically reduced as blood is shunted from numerous areas, including the brain, to the muscles sustaining the workload. At maximal exercise, the brain receives approximately four times less volume per heartbeat, as compared with the resting state. This reduction is precisely offset by the overall increase in cardiac output during exercise (Astrand & Rodahl, 1986).

It's suggested that prefrontal-dependent tasks such as memory number test leads to interruption of the flow experience during physical activity. That working memory refers to the short-term retention of information that is no longer accessible in the environment, and the manipulation of this information, for subsequent use in guiding behavior, many neuropsychological and functional imagery data are consistent with that formulation of working memory. Moreover, many cognitive tasks have been specifically designed to explore particular aspects of working memory functioning. (Collette & Van der Linden, 2000[a,b]; D'Esposito et al., 2000).

The cerebral cortex, and in particular the prefrontal cortex, is at the top of that hierarchy, representing the neural basis of higher cognitive functions (e.g. Frith & Dolan, 1996; Fuster, 2000[a]). Recent advances in cognitive neuroscience have begun to identify the brain circuits underlying the explicit system. Evidence that the working memory buffer of the DLPFC holds the current content of consciousness, coupled with evidence that the executive attentional network of the DLPFC is the mechanism to select the content, suggests that the explicit system is critically dependent on prefrontal regions (Dehaene & Naccache, 2001; Ashby & Casale, 2002; Dietrich, 2003).

Brain imaging studies show that “holding something in mind” is associated with activity in an extended system which involves both prefrontal cortex and more posterior areas whose location is determined by the nature of the information being held in mind (Frith & Dolan, 1996; Fuster, 2000, 2002).

The main advantage of the implicit systems is its efficiency. The mechanism(s) by which knowledge shifts from an unconscious state to a conscious state is one of the most fundamental questions of cognitive science and lies at the heart of consciousness research (e.g. Dulany, 1996; Cleeremans & Jiménez, 2002).

The result of this interaction is a constant and steady perfusion rate. Thus, contrary to popular conception, there is no evidence to suggest that the brain is the recipient of additional metabolic resources during exercise (Dietrich, 2003).

As a consequence of the brain’s finite resources, humans possess a limited information-processing capacity. This is not only true at the bottleneck of consciousness (Broadbent, 1958), where our limited information- processing capacity is a well-established concept that forms one of the cornerstones of cognitive science, but there also exists a total cap on all neural activity, including unconscious, parallel information processing. In other words, because the brain cannot maintain activation in all neural structures at once, the activation of a given structure must come at the expense of others. Such need-based shifts of resources have been observed at a smaller scale in response to treadmill walking.

Studies on CBF and metabolism (e.g. Gross et al., 1980; Vissing et al., 1996) have provided the strongest support for the hypothesis that exercise decreases neural activity in the prefrontal cortex. As cited above, Vissing et al. (1996) found highly significant increases in LCGU in all but a few brain structures, including the prefrontal cortex. This pattern of activity is so striking that extended aerobic running could be regarded as a state of generalized brain activation with the specific exclusion of the executive system (as the other structures in this study do not constitute a large volume of neural tissue). Additional evidence for the hypothesis comes from a human study that correlated the rating of perceived exertion (RPE) with EEG activity (Nybo & Nielsen, 2001).

The prefrontal cortex, at the top of the perception-action cycle, plays a critical role in the mediation of contingencies of action across time, an essential aspect of temporal organization. That role of cross-temporal mediation is based on the interplay of two short-term cognitive functions: one retrospective, of short-term active perceptual memory, and the other prospective, of attentive set or active motor memory (McCarthy et al., 1994; Fuster, 2000; Lewisa & Miallc, 2006).

Evidence from behavioral, neuropsychological, electrophysiological, and neuroimaging studies, from humans, is considered, as is the question of how to interpret delay-period activity in the prefrontal cortex. Working memory is not localized to a single brain region but probably is an emergent property of the functional interactions between the prefrontal cortex (PFC) and the rest of the brain (Postle, 2006; D'Esposito, 2007).

Ulrich et al. 2013 conclude that neural activity changes in these brain regions reflect psychological processes that map on the characteristic features of flow: coding of increased outcome probability (putamen), deeper sense of cognitive control (IFG), decreased self-referential processing (MPFC), and decreased negative arousal (AMY).

These findings suggest that acute bouts of cardiovascular exercise affect neuroelectric processes underlying executive control through the increased allocation of neuroelectric resources and through changes in cognitive processing and stimulus classification speed, additionally, the visual areas demonstrated different degrees of selectivity, and the prefrontal areas demonstrated different strengths of sustained activity, revealing a continuum of functional specialization, from occipital through multiple prefrontal areas, regarding each area's relative contribution to perceptual and mnemonic processing (Courtney et al., 1997; Charles et al. 2003).

It is additionally concluded that psychogenic factors representing the cognitive, affective, and perceptual domains can significantly influence resting as well as exercise metabolism (Morgan, 1985).

According to Kubo et al. (2008), they indicated in physiological manner, an increase of prefrontal cortex blood flow during the performance of the computer version trail making test. This hypothesis explains that the distribution of blood input inside the brain is differentiated. Dietrich & Sparling (2004) in their results showed that during exercise performance on tests demanding prefrontal-dependent cognition was impaired, while at the same time, cognitive processes requiring little prefrontal activity were unaffected. The results confirmed the hypothesis showing that flow during a marathon race is related to future running motivation, but is not directly linked to race performance (Schüler & Brunner, 2009).

Results of a path analysis supported numerous links in the hypothesized model. Findings are discussed in light of research and theory on motivation and flow for master's level swimmers (Kowal & Fortier, 2000). The general conclusion for this exploratory study was that flow experiences appear to be universal experiences for most thru-hikers (Butler, 1999). Hedman et al. (2007) concluded that total flow was unrelated to both visual and verbal working memory.

The ESM yields a corpus of moments in flow, particularly when large numbers of experience samples are collected, but necessarily interrupts the flow experience. Custodero (1998) triangulated interview and observational data to construct a behavioural measure of flow during young children's musical performance. While her primary motivation was to devise a measure of flow for a population with limited capacity to report inner states, her work represents one of the few efforts to identify behavioural markers of flow. The technique is painstaking and time-intensive, however. With colleagues including Fredrik Ullen, one of our current goals is to identify physiological markers of flow that would permit tracking of the dynamics of flow without disrupting it. ESM research suggests that enjoyment and involvement are associated with significantly lower salivary cortisol levels than expected for time of day (Adam, 2005); implying lower stress levels and lower blood pressure.

The phenomenological experience of flow is outlined further by Csikszentmihalyi (1975). Six features are emphasized which constitute an integral part of the dimensions listed previously. First, flow is the merging of action and awareness. A person in flow is aware of his or her actions but not of the awareness itself. By paying individual attention to the task, one cannot reflect on the act of awareness itself. When awareness becomes split, so that one perceives the activity from “outside”, flow is interrupted.

Two theories of the neurobiological basis for flow deserve mention: Dietrich's (2004) hypofrontality theory and Weber et al.’s (2009) synchronisation of attentional and reward networks theory. According to Dietrich (2004). How may coincide with increased activation of the basal ganglia, which subserves implicit cognitive processes that are effortless and automatic, and diminished activation of the prefrontal cortex (or hypofrontality) and structures in the medial temporal lobe, which subserve explicit cognitive processes that demand deliberate control, effort, and awareness. Dietrich's theory is based on neuropsychological research on implicit and explicit cognitive process, but has yet to be tested in people experiencing flow. In contrast to Dietrich (2004). Weber et al. (2009) argue that flow experiences are associated with the synchronisation of attentional and reward neural networks. The reward network is based in the limbic system and includes the dopaminergic system, the orbitofrontal cortex, the ventromedial, and dorsolateral regions of the prefrontal cortex, the thalamus, and the striatum. The attentional processes relevant to flow experiences involve the frontal and parietal cortical regions, which subset c alertness, and superior and inferior parietal lobe regions, the frontal eye folds and the superior colliculus, which sub serve orienting. According to Weber et al. (2009), during non these attentional and reward neural networks “fire” at a synchronous rate. In a functional magnetic resonance imaging (fMRI) study. Weber and his team showed that as the state of flow induced by playing a video game decreased due to increasing experimentally controlled distractions, the synchronization between attentional and reward neural networks also decreased. Further fMRI studies are required to assess the relative validity of Dietrich's (2004) hypofrontality hypothesis and Weber et al.'s (2009) synchronization of attentional and reward networks theory.

Another problem for many rowers is focusing on factors that are outside of one's control. These include distractions such as the competition, weather, water conditions, a bad warm-up and previous race mistakes. There is very little that can be changed, if anything at all, about these factors so there is no benefit to thinking or worrying about them. These thoughts are guaranteed to disrupt your concentration and prevent you from achieving the flow state.

- It is assumed that the neural activation of prefrontal cortex using Classification Number Test in comparison with Stimulus Response Test and the No-Intervention-Control-Condition under the Own Zone "hard" running on treadmill leads to high significant Flow by CNT measured by female test persons after 20 min running.

The results of the study showed a significant difference to the gender factor, which can be discussed in many psychological-biological directions and can be supported from many scientific papers, although it's sometimes not significant.

Previous research has examined flow and sports in order to better understand how athletes enter flow. For instance, recent research has examined possible ssociations between Flow and Sport, Team Sports and Flow, and Flow and team Sports Gender. (Flood & Hellstedt, 1991; Young & Pain, 1999; Russell, 2001; Takuya, 2005).

With the reference to hypothesis of Tenenbaum et al. (1999) their analyses conducted here that when in the flow state, females are more conscious of enjoyment, males of competency. Results of Inal & Cagiltay (2007) revealed that flow experiences occur more among boys than girls during gameplay, but narratology had more effect among girls.

The purpose of this study was to investigate whether any differences in flow, as measured by the Flow State Scale-2 (FSS-2) (Jackson & Eklund, 2004), exist between men's and women's soccer at the intercollegiate level. The results indicated that there is significantly different between males and females in these points 1). Overall total flow score was significantly higher for females than males ($p = .001$). The value of the t-test was -3.77 with 31 degrees of freedom. 2).

The t-test was significantly different between males and females on the balance/skill attribute of the FSS-2 scale at ($p = .019$). The value of t-test was -2.478 with 31 degrees of freedom. 3). The t-test was significantly different between males and females on the autotelic attribute of the FSS-2 scale ($p = .000$). The value of the t-test was -7.937 with 19.8 degrees of freedom (Larson & Oregon, 2008).

Flood & Hellstedt (1991) examined the participation motives of 161 intercollegiate athletes at a medium sized public university in the Northeastern United Sates. The study examined the difference between male and female intercollegiate athletes in sport motivation.

Participants consisted of 116 males and 45 females. Students ranged in age from 18 to 28 with a mean age of 20. One hundred and sixty four of these students were white and 7 were black students. Most of the participants in this study participated at the division II level of the National Collegiate Athletic Association.

Participants were administered a questionnaire during a team practice or meeting. The questionnaire was an adaptation of the participation motivation instrument developed by Gill et al. (1983). Participants were then asked to rate the items on a 9-point Liker type scale (Flood & Hellstedt, 1991). Gender differences were then compared on each item using MANOVA and t-test. Additionally, the researchers conducted a secondary analysis which compared members of the men's and women's teams in order to provide a comparison between males and females participating in the same or similar sport. Results from this experience identified that making friends, learning new skills and exercise are more important motives for females than for males.

According to Hungarian psychologist Mihalyi Csikszentmihalyi, the highest level of intrinsic motivation is flow state. Flow is characterized by complete immersion in an activity, to the degree that nothing else matters. Central to the attainment of flow is a situation in which there is a perfect match between the perceived demands of an activity and an athlete’s perceived ability or skills (Csikszentmihalyi, 1975, 1990).

Results of Gillet & Rosnet (2008) indicated significant differences between males and females, $F(8, 276) = 4.98$, $p < .001$. Univariate F values indicated that male and female athletes differed on intrinsic motivation, $F(1, 283) = 4.02$, $p < .05$.

The present results also showed that male athletes exhibited more external regulation and less intrinsic motivation than female athletes. In other words, females appeared to take part in sport activities for the pleasure derived from the activity itself more than for extrinsic motives. These results were in line with past studies in the sport context (e.g. Fortier et al., 1995; Chantal et al., 1996) and confirmed that gender differences should be taken into consideration in the sport domain.

The results of this research shows female athletes have higher levels of intrinsic motivation as compared to male athletes (Monazami et al., 2012). This finding is consistent with the results of Chantal et al. (2001) who compared the sport motivation of male and female elite Bulgarian athletes, both title and medal holding athletes and those who had won no medals or titles.

Experiencing flow in different types of physical activity intervention programs: three randomized studies, showed that when comparing the sport types of running and football in samples 1 and 3, football appears to elicit lower worry values for the males than the females (Elbe et al., 2010).

Hellandsig (1998) found evidence to support the fact that females participated more for friendship while males participated more for competition and the satisfaction of winning. Secondly, showed that women showed higher levels of intrinsic motivation in comparison to their male counterparts (Chantel et al., 1996). Also, Gould et al. (1985) noted that even children differ in their motivation based on their gender. Specifically, that females place greater emphasis on fun and friendship, while males do not.

The quantitative results from the flow state scale assessment provided empirical support for the construct of flow for males and females across team and individual sport settings. The non-significant results for gender and sport setting indicated that the college athletes experienced flow factors similarly, regardless of gender or sport setting (Russell, 2001).

The dynamic process of the organizational factors is different according to gender and psychopathology resulting from the combinations of behaviors, cognitions and emotions would be assumed, prioritizing physical aggression and psychopathy by boys, anxiety and depression by girls, a structural model enhances the role of perfectionism in the cognitive and behavioural contexts; for instance it clarifies its action on fear of failure and success rates according to gender (Masson et al., 2003, 2004).

There are known differences between the central nervous systems and the hormonal milieu of growing children of different genders (Giedd, 2004). These results demonstrate differential patterns of activation in males and females during a variety of cognitive tasks, even though performance in these tasks may not vary, and also that variability in performance may not be reflected in differences in brain activation (Bell et al., 2005).

Female group had higher cerebral blood flow velocities (CBF) of both the middle cerebral artery (MCA) and the basilar artery (BAS), (Monica et al., 2005). In addition, Rodriguez et al. (1988) indicated that the female flows were more symmetric. As a hypothesis, it is suggested that the higher flow level in women may be a systemic phenomenon. In fact, other authors have found a higher cardiac index in females. The sex differences in regional flow pattern might be due to differences in the functional organization of the cortex and/or to differences in the mental processes of the "resting" state.

In a recent study, Young (1999) examined flow experiences of 31 Australian professional female tennis players. Adopting dual flow theory and reversal theory frameworks, the study found evidence to support both theoretical conceptualizations of flow.

- It's assumed that the performance of CNT Index leads to high significant difference measured by whole test persons after 20 min running in Own Zone "hard" level in comparison with the setting position.

In this experiment we found that the cognitive performance in the Classification Number Test was significantly increased during running on the treadmill, compared to sitting position. It's proven in many studies that sport activity has positive effect on the cognitive achievement. Winter et al. (2007) found that vocabulary learning was 20 percent faster after intense physical exercise as compared to the other two conditions. This condition also elicited the strongest increases in BDNF and catecholamine levels. More sustained BDNF levels during learning after intense exercise were related to better short-term learning success, whereas absolute dopamine and epinephrine levels were related to better intermediate (dopamine) and long-term (epinephrine) retentions of the novel vocabulary. Thus, BDNF and two of the catecholamines seem to be mediators by which physical exercise improves learning.

It has been well documented that exercise in the moderate, aerobic range is beneficial to mental health (Glenister, 1996; Scully et al., 1998; Salmon, 2001). Researchers have also established that exercise results in a mild enhancement of cognitive function (Etnier et al., 1997; Kramer et al., 2000; Hall et al., 2001; Colcombe & Kramer, 2003; Tomporowski, 2003).

A careful review of the empirical literature reveals that in most studies cognitive ability was evaluated at least 10–15 min after the exercise bout had ceased, presumably to control for arousal levels as well as a number of other possible physiological confounds (Magnie et al., 2000).

Exercise is beneficial to mood and cognition (Scully et al., 1998; Colcombe & Kramer, 2003; Tomporowski, 2003). Extensive evidence shows that in the moderate, aerobic range, exercise reduces stress, decreases anxiety, and alleviates depression (Salmon, 2001). Despite decades of research attempting to explicate a neurochemical basis for these phenomena, a sound mechanistic explanation is still lacking. Previous research has concentrated heavily on alterations in neurotransmitter mechanisms such as norepinephrine (Dishman, 1997), endorphins (Hoffman, 1997), serotonin (Chaouloff, 1997), and most recently endocannabinoids (Sparling et al., 2003; Dietrich & McDaniel, 2004).

In the only PET study published to date, increased brain activation was recorded in the primary sensory cortex, primary motor cortex, supplementary motor cortex as well as the anterior part of the cerebellum in response to cycling (Christensen et al., 2000), while the only published single photon emission computed tomography study found increases in regional CBF in the supplementary motor area, medial primary sensorimotor area, striatum, visual cortex, and cerebellar vermis during walking (Fukuyama et al., 1997).

Exercise also activates structures involved in sensory, autonomic, and memory function, particularly primary and secondary sensory cortices, sensory pathways, brainstem nuclei, hypothalamus, and the sensory thalamus. Kramer & Erickson (2007) suggest that physical activity enhances cognitive and brain function. Moderate levels of aerobic activity are sufficient to produce significant improvements in cognitive function with the most dramatic effects occurring on measures of executive control. Kramer et al. (2006) conclude with a summary and brief discussion of important future directions of research on fitness cognition and brain.

Stein et al. (2007) mentioned that there is growing basic-science interest in the mechanisms underpinning the positive effects of exercise on brain function and cognitive-affective performance.

The study of Ferris et al. (2007) showed that the cognitive function scores improved after all exercise conditions. Exercise is beneficial to mood and cognition (Scully et al., 1998; Colcombe and Kramer, 2003; Tomporowski, 2003).

There are few studies that attempted to test for cognitive functions during exercise (e.g. Youngstedt, et al., 1993; Brisswalter et al., 1997; Fery et al., 1997; Arcelin et al., 1998; for recent reviews see Brisswalter, et al., 2002; Tomporowski, 2003). Collectively, cognitive testing in these studies was limited to either basic choice reaction time and/or visual recognition tasks.

6 Conclusions and Future Directions

The transient hypofrontality hypothesis of flow (Dietrich, 2004) is based upon the idea that the brain has the same amounts of resources regardless of the level of physical activity. Due to this limited resources, the sustained neural activation during aerobic exercise results in the temporary inhibition of brain structures currently unessential to the activity, namely the higher cognitive centers of the prefrontal cortex.

The sample (N = 33) consisted of 11 female and 22 male running experienced test persons, from it were students in the sport science and students from other studies fields. The average age of the women was 22.8 years (SD = 1.25), that one of the men amounted by 23 years (SD = 2.07). The test persons answered voluntarily on a public call which has been put up in different places of the university.

The investigation carried out in the training scientific laboratory of the institute for Performance Diagnostics and Health Promotion at the Martin-Luther University Halle-Wittenberg. The test subjects have to absolve a 30-minute running on treadmill. They should stay with it within a first of all defined person specific intensity area.

The determination of this personal heart rate target zone (OwnZone®) based on scientific knowledge to the behavior of the heart rate variability at rising load intensity (Tulppo et al., 1996; Laukkanen et al., 1998; Hottenrott, 2006).

At this treadmill investigation it is particular that the intensity of running was not determined by the adjusted velocity but the treadmill velocity was controlled according to the heart rate of the runner automatically. For this comes especially a programmed treadmill (Pulsar 3.0 of the company h/p cosmos) for use. The influencing of the velocity over the heart rate represents a stress oriented control. The area of OwnZone® was chosen "hard" approx. 80-90 % of the maximal heart rate to make sure that all runners are exposed to manageable demands above average.

PE-students (N = 33) had to run on a treadmill within three test specifications. In the first experimental-condition, prefrontal-dependent abilities were tested using a Classification-Number-Test. To ensure that the measured effect is not due to a distraction of attention, in control-condition two, the students had to perform a test of prefrontal-independent abilities (Test of Reaction Time). A third control-condition was realized without any additional tasks. Flow was measured using the Flow-Short-Scale (Rheinberg, 2003).

The most important result of the study, which showed that the activation of the prefrontal cortex through the Classification Number Test disrupted directly the flow experience or the flow state of the all test persons. Another finding was the higher flow state by females after the questionnaire of Flow-Short-Scale (Rheinberg, 2003), in the 20 min running on treadmill. The Classification Number Test Index by running showed higher values than in sitting.

From the knowledge of this study, meaningful conclusions can be closed for the prefrontal hypofrontality and physical activity under laboratory conditions:

First, this study gives a good example for the interaction between three science fields (sport pedagogy, psychology, and physiology). The research has shown an improvement in the cognitive performance of the classification number test on the treadmill. On the other hand, the study shows the relation between Flow experience, a kind of positive intrinsic motivation and the activation of the prefrontal through classification number test, which interrupts the Flow experience.

The Flow experience is different in dependence of the test condition and the sex. The activation of the prefrontal cortex area on the brain with classification number test has a considerable influence on the Flow experience during the running on the treadmill.

The Flow experience for female test persons has under the classification number test higher value in comparison of male test persons, which can lead back to biological-psychological symptoms.

The cognitive performance of Classification Number Index for the both male and female test persons on the treadmill after 20 min indicate that physical activities have positive effects on prefrontal cortex activation. The classification number index during running was higher than the values in sitting.

All in all, the results verify the transient hypofrontality hypothesis and reveal the problems of Questionnaires. As they are applied, the prefrontal cortex gets activated and the flow experience is interrupted. In contrast, the activation of prefrontal cortex has led to significant decreasing of the flow experience using the Classification Number Test after 20 min of the running on the treadmill.

More research are needed to determine the flow experience in relation to the anxiety, as the anxiety values didn’t show significance when the prefrontal cortex activated during the Classification Number Test.

Based on these findings, recommendations are made including the need for researchers to move from description to explanation of flow, the use of new methodologies, greater focus on the role of prefrontal cortex activation, and possible refinements of existing flow theory under laboratory conditions to be more specific to sport.

Finally, it’s strongly recommended to investigate the flow experience with new methodologies, greater focus on the role of prefrontal cortex activation, and possible refinements of existing flow theory under laboratory conditions to be more specific to sport. These new methodologies can be combined with psychological-physiological and -neurological variables such as HRV, EEG, Brain Metabolism and Magnetic Resonance Imaging (MRI), Nuclear Magnetic Resonance Imaging (NMRI), or Magnetic Resonance Tomography (MRT), which can introduce a deeper review to the flow interruption and the role of the prefrontal cortex activation.

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Appendix

Abbreviations

%	Percent
&	And
*****	Significant
******	High Significant
®	Trade mark
approx.	Approximately
AS	Anxiety Scale
BDNF	Brain-Derived Neurotrophic Factor
ca.	Circa
cf.	Compare
CNT^{Index}	Classification Number Test Index
CS	Corrugator Supercilii
CSAI-2	Competitive State Anxiety Inventory-2
e.g.	For example
EDA	Electrodermal Activity
EMG	Electromyography
ESM	Experience Sampling Method
ESM	Experience Sampling Method
et al.	And others
etc.	Et cetera
ex.	Example
Fig.	Figure
FKS	Flow Short Scale
$Flow^{CNT}$	Flow of Classification Number Test
$Flow^{SRT}$	Flow of Stimulus Response Test
$Flow^{WAT}$	Flow Without Additional Tasks
FSS	Flow State Scale
i.e.	In other words
IZOF	Individualized Zones of Optimal Functioning
JDFS-2	J. Dispositional Flow Scale-2
JFSS-2	J. Flow State Scale-2
KG	Control Group
l/min	Liter pro minute
La^{Post}	Post Lactate Concentration
min	Minute
ml/min	Milliliter pro minute
N	Number of Test Persons
n	Number of Males or Females
o.a.	On account
p.	Page

PFC	Prefrontal Cortex
Pt.	Part
rCBF	Regional Cerebal Blood Flow
SAS	Sport Anxiety Scale
SCAT	Sport Competition Anxiety Test
SCL	Skin Conductance Level
SD	Standard Deviation
SEES	Subjective Exercise Experiences Scale
SNS	Sympathetic Nervous System
STAI	State Trait Anxiety Inventory
Tab.	Table
VG	Test Group
VT	Ventilatory Threshold
WCST	Wisconsin Card Sorting Task
YPAS	Yale Physical Activity Survey
ZM	Zygomaticus Major

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2004	Master for Sports Science (excellent), El Minia University

Ph.D. Special Field:

Sport Pedagogy and Sport Psychology (Technology Methods for Learning)

Specific Training:

Control by language of the deaf and mute, learned in Canada
Practical experience with Obstructed and senior care, in Canada
Participation at project “Flow Experience under Laboratory Conditions”

Languages:

German, English (very good), French (middle) and Arabic (Mother Language)

Computer Skills and Special Qualification:

ECDL-Certificate (European Computer Drive License)
National Karate Athlete and Trainer, Music and Journeys

Published Scientific Papers:

Christian Reinhardt, C. & Youssef, H. (2009). Flow and Hypofrontality. 2nd Annual Meeting of the Society for the Study of Motivation (SSM). San Francisco, USA.

Halle(Saale), den 30.09.2013

Heba Saad Aly Youssef

Heba youssef

Declaration

I declare under penalty of perjury, that I have used the present work independently and out of any other specified literature.

Halle, den 30.09.13

Heba Youssef

Heba youssef