Neuroscience of Flow States

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Flow states have been shown to help people reach peak performance, yet this elusive state is not easily attained. This entry describes the current state of literature on flow by addressing the environmental influences as well as the cognitive and neurocognitive elements that underlie the experience. In particular, the research focuses on the transition of cognitive control from an explicit to an implicit process. This is further expanded upon to look at the current, yet related neurocognitive research of high performance associated with the implicit process of automaticity. Finally, this entry focuses on transcranial direct current stimulation (tDCS) as a novel method to facilitate the induction of flow states.

Keywords: flow ; expertise ; tdcs ; cognitive control ; decision making ; eeg ; automaticity ; neurocognition

1. Introduction

The scientific community has as of late begun to explore the field of expertise and its components. One element however that has begun to gain a growing amount of attention is the peak performance found in flow states, whether it be in sport, business or other professional endeavors. Flow is described as a state of optimal performance denoted by smooth and accurate performance with an acute absorption in the task to the point of time dissociation and dissociative tendencies[1][2][3]. In the modern workplace there are so many distractions, from messages to meetings, that result in a reduction of productivity. Yet a 10-year longitudinal study Cranston and Keller[4] showed people in flow states were 500% more productive. Whilst much research has been performed on the personality components of flow there is still much to explore when it comes to the neurocognitive underpinnings of flow to better understand the workings and catalysts for this elusive state. This review focusses on describing the current state of flow research on neurocognitive understandings and provides an insight into the key theories and experimental implications being presented in the research surrounding flow states.

Transcendent, spiritual experiences similar to flow states have long shared reports with countless of religious references dating back centuries by spiritual authors. Flow then found its entrance into the mainstream with Maslow[5] 'peak experiences' and has since been appropriated into popular culture with many names including "in the zone" and "in the moment". Although a long history exists of this high functioning state, much of its inner workings and route of initiation is shrouded in mystery. Csikszentmihalyi[6] first described the flow state and noticed the conditions for entering this experiential state include a balance of challenges or action opportunities with an individual's skill as well as clear and well-defined goals with immediate feedback.

According to Csikszentmihalyi[7] flow theory, the flow experience relates to the skill set perceived to be possessed by the individual relative to the perceived challenges of the activity. Challenges can be considered as "opportunities for action" thus flow is produced by any situation that requires skill[3]. The phenomenology of flow further suggests that the enjoyment of a task is due to a discovery found within the interaction of the task. For instance, at first the task might appear boring or anxiety provoking but if the action opportunities become clearer or the skill level improves the task becomes more engaging and finally enjoyable. The discovery of more complex behaviors results in an emergent motivation that transforms a previously unengaging task into that which is intrinsically motivating[8]. Therefore, complexity of the skill must increase to meet the increasing complexity of the task's challenge in order for the person to remain in flow. Csikszentmihalyi[7] developed the flow state model to help illustrate this state change as seen in Figure 1. For instance, when the challenges and skills are low, a person will likely experience apathy, considered an experience of the lowest quality and the lowest intensity on the flow state model. Whereas, when the skills are greater than those needed for the challenges, the person is more likely to experience boredom/ relaxation, considered an experience of higher quality than apathy. As the level of challenge increases, the experience moves toward control. In contrast to this, when challenges are greater than the skills required by the person, the experience of worry/ anxiety is more likely. Then as the skill level increases, the experience moves toward arousal. Therefore, based on this model, flow states are believed to be accessed when skills and challenges are both high and in equilibrium, resulting in an experience of the highest quality[9].

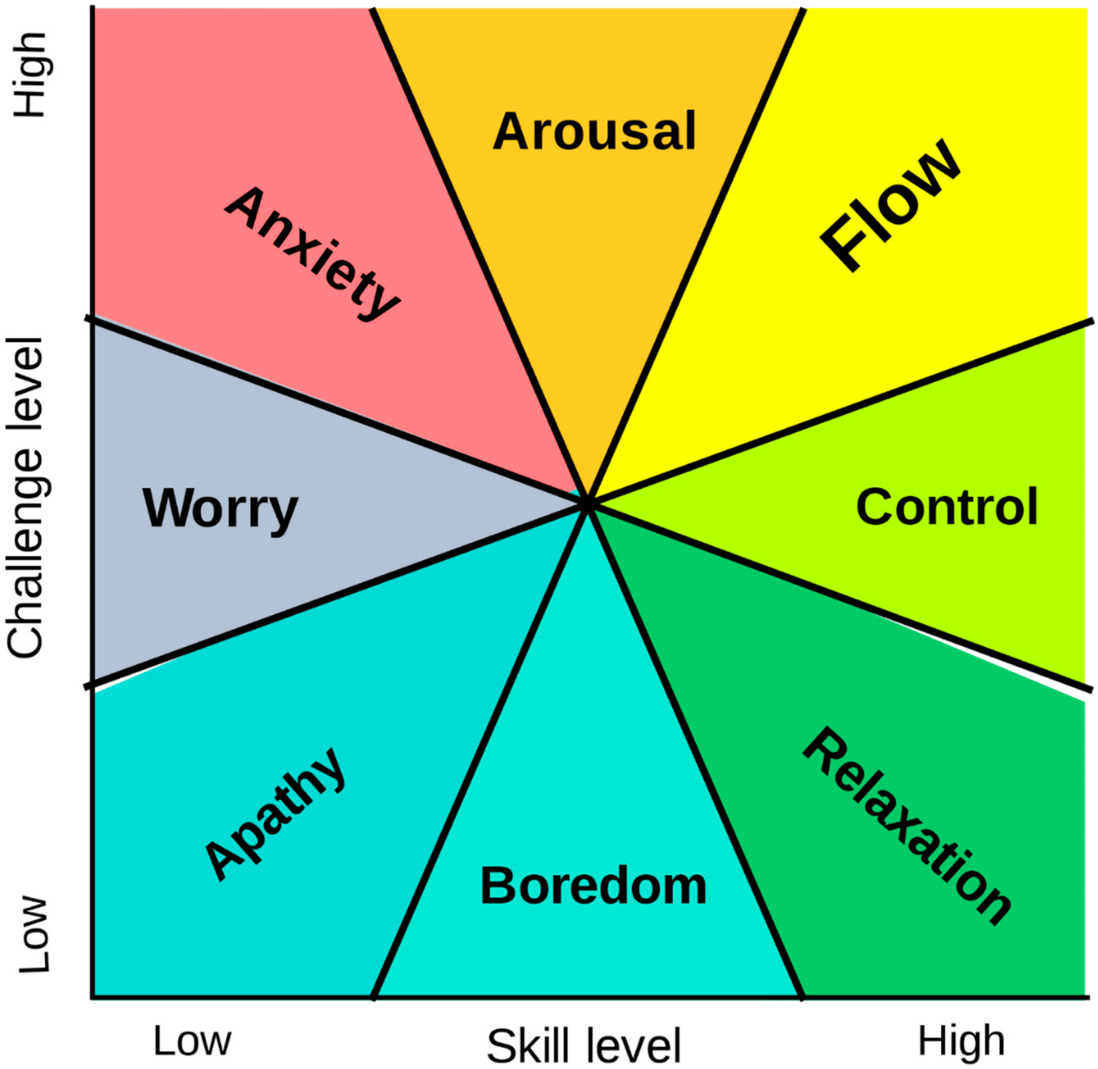

Figure 1. Csikszentmihalyi's flow model[7] describes psychological states in terms of challenge level and skill level.

Nonetheless, flow rarely occurs in everyday life because challenges and skills are rarely balanced, but even these two parameters do not guarantee flow. Therefore, flow requires activities to have a further set of particular criteria [9]. Firstly, the activity typically requires learning of skills, and have clear goals with quick and unambiguous feedback. This affords a sense of control over reality by understanding what needs to be done and how they are performing. This activity design also works best when concentration and involvement is facilitated by separating a person from their everyday existence by focusing on the particular reality of the activity, such as particular uniforms and special rules of the activity that are not necessarily relevant to everyday living[9].

People in flow mention that they become so absorbed in the activity that they do not have any attention to spare to become distracted by anything else. People have also mentioned a collection of other psychological phenomena associated with states. These include: (a) a feeling of control over the activity; (b) an experience of time distortion, in which a person loses awareness of how time is passing (c) the removal of self-consciousness in which a person loses the awareness of themselves as well as thoughts of everyday problems; (d) a feeling of transcendence where the person feels a sense of unity with the activity. See Table 1 for a list of full 9 components.

Table 1. Nine components associated with the flow state experience[9] (Csikszentmihalyi, 1990).

1. Clear goals (expectations and rules are discernible, and goals are attainable and align appropriately with one's skill set and abilities).

2. High level of concentration, a high degree of concentration on a limited field of attention (a person engaged in the activity will have the opportunity to focus and to delve deeply into it).

3. A loss of the feeling of self-consciousness, the merging of action and awareness.

4. Distorted sense of time, one's subjective experience of time is altered.
5. Clear and immediate feedback (successes and failures in the course of the activity are apparent, so that behavior can be adjusted as needed).
6. Balance between skill level and challenge (the activity is neither too easy nor too difficult).
7. A sense of personal control over the situation or activity.
8. The activity is intrinsically rewarding, so there is an effortlessness of action.
9. People become absorbed in their activity, and the focus of awareness is narrowed down.

Therefore, when a person has a perceived adequacy of skills matched with above average challenges, as part of a goal-directed, rule bound system that provides clear feedback, the person can find complete absorption that removes the possibility of any distractions from thoughts irrelevant to the task at hand. In this focused space a person has an opportunity to find such a level of immersion in the activity that they will feel an inspired sense of control, a complete removal of self-consciousness, a distortion of time and a feeling of transcendence.

Furthermore, it has also been found that flow states can be reached by any person performing any sort of task as long as they can ascertain an adequate level of skill. These levels of skill require an expertise that can afford the smooth performance state associated with flow and consequently with higher expertise is believed higher flow values[10]. Many people were studied in many different situations and all were able to achieve the optimal experience from the activity. Flow states have become such common place in all areas of society that people use many ways of describing the state such as "wired in", "in the groove", "in the moment" and "the zone" to name a few. This experience has typically been described throughout the ages as forms of religious fervor but now has moved into the current day through many other forms of engaging activities. Flow has been recorded in everything from business transactions, sports, video gaming, music, art and yoga. These flow states all share in a series of similar characteristics that were attributed to flow by Csikszentmihalyi. It is the subjective challenges and skills, not the objective ones, that impact on the quality of a someone's experience[8]. Numerous studies have further highlighted the similar subjective experience of flow states in various activities, such as sport[11][12], skateboarding[13], education[14] to name a few. No matter what the activity, the elicitation of this flow state is considered by many to be the "Holy Grail" of performance[15].

2. Flow Functions

As flow states are considered a complex combination of multiple cognitive features it has been difficult to delineate specific neurocognitive markers. Studies for the most part still rely on a mix between psychophysiological measures and probing post-task self-report questionnaires. The conflict still remains that as soon as the participant is asked about their experience, they are forced to self-reflect which will move them out of the flow state. We can therefore begin to break down some of the key neurological elements to test whether they can be defined as key elements of flow states in order to further identify key elements that may be relevant to the neurocognitive functionality of flow states. Particular elements of flow to be defined are that it occurs within an activity which is balanced with an individual's abilities, whilst fully immersed in the task and self-referential thoughts are completely inhibited. However, we can look at previous studies looking at similar cognitive functions such as expert performance, creativity, focused attention and mental workload to help delineate neurocognitive landmarks that will help us identify the elements of flow activity.

The EEG is a well validated measure for examining psychological states during skilled motor performance[16][17]. In particular, results have highlighted the left frontal and temporal regions as playing key roles in expert performance with increased alpha power in EEG occurring in expert marksmen compared to novice shooters[16][17][18]. EEG has also been used across a range of activities including weightlifting[19], golf[20] and archery[21] all revealing a reduction in left hemispheric activity. In a recent study, a comparison of neuro-anatomical characteristics also showed that expert divers have significantly increased cortical thickness in the left superior temporal sulcus compared to the non-athlete group[22]. The superior temporal gyrus houses several important cortical structures, including Wernicke's area known to be involved in the comprehension of language. To follow on, this pattern of increased alpha activity in the left temporal region has been most commonly interpreted as representing a reduction in cortical activations, reducing verbalizations associated with the left brain and enabling more resources to be allocated to the visual-spatial processes of the right brain[23]. This has been further supported by lower coherence estimates of left temporal regions with motor regions by expert marksmen[24]. This pattern suggests less cortico-cortical communication and a suppression of analytic processing influence thus simplifying a complex process and alleviating the need for a division of cognitive resources.

Additionally, a key antecedent of flow utilizes the challenge/skills-balance which indicates a state of high mental workload from deep involvement in the task[9]. This has been shown in psychophysiological studies on flow, in which decreased heart rate variability was shown during challenge/ skills-balance in a knowledge task[25]. EEG has also been used to evaluate mental workload in which a reduction of alpha activity and an increase of theta is present due to the tasks increased difficulty levels[26][27]. Alpha frequencies are categorized into three frequency bands (8–13 Hz, 8–10 Hz, and 11–13 Hz). Alpha activity in general (8–13 Hz) represents lower levels of consciousness and awareness, while an alpha reduction results in increased mental activity[28]. The low alpha band (8–10 Hz) is associated with the mechanisms of arousal, attention and effort as well as general cognitive processing while high alpha (11–13 Hz) selectively acts according to the encoding of the stimulus[29].

Sports performance has also been shown to improve when implementing hypnotic techniques using flow state suggestions[30][31][32]. It is not yet understood how hypnosis increases performance or the experience of flow. One suggestion by Crawford and Gruzelier[33] is a shift is made from an analytical think style to become more holistic after hypnosis, allowing access to processes that are important for athletic performance. Shifts from the left (analytical verbal and conscious side of the brain) to the right hemisphere (holistic, nonverbal, imaginative side of the brain) have been shown during hypnosis[34]. It has been further shown that there are strong correlations between hypnosis with absorption[35]. A correlation has also been shown between absorption and dissociation, in which the ability to become absorbed in a task is another way to induce dissociative control[36]. Task absorption and dissociation are considered key component to the higher levels of the flow phenomenology.

Additionally, theta activity has been shown as relevant for evaluating cognitive processing during flow like tasks such as meditation. Lutz et al.[37] experienced meditators and novices were tested at the beginning and end of a three-month meditation retreat, using an attentional blink test. In experienced meditators, results significantly improved whilst presenting increased theta phase-locking, i.e., a reduced variability of theta phases across trials. These results are considered to show a more stable execution of neural processing[38]. Furthermore, multiple fMRI studies have highlighted attentional networks providing support for increased activity in prefrontal networks during focused[39], meditation-like attention[40].

Positive affect and motivational orientation, two elements associated with flow phenomenology, have also found links to changes in frontal EEG asymmetry[41]. In particular, increased left alpha frontal activation was correlated with approach-related motivation[42]. This is also shown by higher activity of the frontal left associated with trait measures of behavioral activation[43]. Specifically, positive emotions were correlated with high left frontal activity, while negative emotions were correlated with increased relative right frontal activity[44]. Ultimately a pattern of the relationship between frontal EEG asymmetry, motivational direction, and affective valence has been shown for performance settings.

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