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The Role of Spontaneous Thoughts in Human Cognition

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Abstract. Spontaneous thought is a cognitive process that ubiquitously happens in daily life. Humans spend 30-50% of their lives in spontaneous thinking, but the impact and consequence of spontaneous thought have not been widely studied in cognitive neuroscience. It is crucial to expand the research involving spontaneous thought since it benefits human's memory encoding and decision-making abilities. This review has two main aims: the first is to explore the cognitive impact of goal-directed and spontaneous thought; the second is to discover the benefits of spontaneous thought to humans. This paper concludes that spontaneous thought has the role of improving memory encoding and facilitating future planning.

1. Introduction

With the development of computational neurology, the 20th century has been named the era of neuroscience. Neurologists start to fill the research gaps such as the mechanism and process of cognition. The cognitive system has two main pathways—goal-directed thought and spontaneous thought—communicated and transmitted by neurons. Scholars have conducted extensive research in goal-directed thought and highlighted its robust capacity in modulating neurofeedback [21]. They pointed out that goal-directed thinking was closely associated with personal achievements [18]. However, the role of spontaneous thoughts in human cognition has not been fully studied yet.

The significance of spontaneous thought should not be ignored since it occurs rather frequently in daily life. Spontaneous thoughts are the shift from the external environment to intrinsic ideas [27, 29], occurring during wakefulness and sleep [17]. Research showed that humans would allocate 30–50% of their daytime for spontaneous thoughts and spend over 79.6% of their time in mind wandering—a form of spontaneous thought [27]. Several features of spontaneous thoughts have been revealed in the past research, such as the positive impact of complex tasks on spontaneous thoughts [9] and the strong correlation between spontaneous thoughts and emotions [10]. These findings suggest the complexity of spontaneous thought and the value of exploring it.

Discovering the role of spontaneous thought in cognition is essential because (1) human consistently performs it despite spontaneous thought has not been thoroughly understood; (2) studying the role of spontaneous thoughts would promote the understanding of the dynamic of neurocognitive networks in the brain; and (3) discovering the impacts of spontaneous thought may have an educational and social significance because distractions carried by spontaneous thoughts have salient influences in lecture listening and business working.

Normal intuition often considers spontaneous thoughts as useless messages or random ideas. It might be valid to some extent, but the current study of spontaneous thought points out that it has benefits that people have underestimated for a long time. This review will use three sections to emphasize these benefits, beginning with the definition and current finding of cognitive thoughts. The second session will discuss two impacts of spontaneous thought on human cognition. The benefit of

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spontaneous thoughts in decision making and memory encoding will be further discussed in the last part of this review.

2. Two types of cognitive thoughts

2.1. Goal-directed thought

Goal-directed thought refers to oriented and conscious ideas, especially when people solve problems or do teamwork. Preliminary work in this field carried out that most behavioral activities were goal-directed, meaning most actions were controlled by cognition instead of immediate stimuli [21]. With goals in mind, the brain could switch its original state and generate strong neurofeedback—a form of biofeedback providing simultaneous self-modulation [21]. Neuroimaging experiments further suggested that goal-directed thoughts shared two characteristics: (1) actions were expected to achieve desired outcomes, and (2) the actions were guided by the "interplay between prediction, control, and monitoring" [25]. The brain region that connects to the goal-directed thoughts is the lateral prefrontal cortex (PFC) [26], and damage in PFC would cause dramatic dysfunctions in making goal-direct decisions [31, 20]. During the cognitive control process, the sub-regions of PFC—right dorsolateral PFC (DLPFC) and rostrolateral PFC (RLPFC)—play an essential role in signaling another neuronal region. PFC is also important in providing human perceptual cognition, the intention of actions, and anticipatory abilities [13, 26].

2.2. Spontaneous thought

Spontaneous thought refers to the mind shifting to a task-unrelated and stimulus-independent thought, standing as an opposite to the goal-directed thought [16]. The content of spontaneous thought composes the episodic memory and frequently happens when there is no apparent intention [23]. Recent studies discovered an association between the left hippocampus region and spontaneous thought, indicating spontaneous thought was a cognitive behavior [20, 28]. As neurologists noticed the action potentials of neurons in the lateral and medial temporal lobe, spontaneous thought was proved to link to memorization capacity [22].

2.2.1. Mind wandering. Mind-wandering is a particular type of spontaneous thought. It could have positive, neutral, and negative effects, depending on individual situations and their environmental complexity [2]. The positive effects include promoting creativity and future planning, while the negative effects would lead to errors or getting distracted during a cognitive task [16]. Scholars showed that 60% of mind-wandering was episodic in nature, and 77% of the mind-wandering was related to a specific event. They further argued that the increase of mind-wandering will cause a decrease in cognitive demands [13].

2.2.2. The distinction between spontaneous thought and mind blanking. Mind blanking means the absence of thought, while spontaneous thought refers to random ideas. Moreover, the cognitive effects between spontaneous thought and mind blanking are different. The subject with spontaneous thought tends to perform worse in prose memorization, while the subject with mind banking likely acts worse in complex planning tasks [20]. Research also showed that patients with depression tend to do more mind blanking than mind wandering [2].

3. The impact of spontaneous thoughts on humans

3.1. Sleep

Spontaneous-thought trials were found to be more frequent in the wake (75%), compared with N2 sleep (45%) and REM sleep (65%) [24]. It means that spontaneous thought primarily appears during wakefulness, but it could continue during sleep [17]. Sleep is a cortical-modification period at which both consolidation and activation of memories happen. Internal pulse generators such as the

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anterolateral pons—the most significant part of the brain stem—render spontaneous activation of past thoughts or forgotten memories [8]. The medial temporal lobe structures—including the hippocampus which generates spontaneous thoughts—are associated with memory consolidation [19]. Overall, the spontaneous thoughts that occur during sleep seem to have the function of exciting memories, incorporating old thoughts, and integrating new ideas in the process of thought consolidation. Kamiński et al.'s study further argued that memory consolidation and reconsolidation appearing during wakefulness and sleep help improve memory [14].

3.2. Emotions

Spontaneous thought connects with emotions and can predict life satisfaction [3]. People tend to construct spontaneous thoughts because those thoughts can serve as a modulation for tedious or challenging tasks. For example, Paton et al.'s experiment suggested that mind wandering and fantasy engagement would lead to less anger when participants were shown aggressive or abusive images [12]. This indicates that mind wandering can generate positive emotions and regulate the feeling of anger. However, other scientists question this positive relationship, arguing that mind wandering and spontaneous thought will increase negative emotions. This view could be supported by Killingsworth and Gilbert's study. They pointed out that cognitive processes arrived at the cost of pleasing emotions ($P < 0.001$), and mind-wandering would not provide psychological and mental relief. Their results further suggested that participants were more likely to wander to pleasant topics ("42.5%" of samples) than to unpleasant topics ("26.5%" of samples) or neutral topics ("31%" of samples) [15]. However, there was no difference in participants' emotions when they thought about pleasant topics relative to their initial emotions, but they were significantly unhappier when thinking about neutral or unpleasant topics relative to their original emotions. Killingsworth and Gilbert finally concluded that unpleasantness was discovered when the subject was mind wandering. This unpleasing emotion would even cause further mind wandering, resulting in a vicious circle [2].

4. The benefits of spontaneous thoughts on human cognition

Studies showed that spontaneous thoughts could have benefits if they were "constrained." Spontaneous thoughts are "constrained" when people unconsciously wander an impersonal and objective topic rather than a fantastic and emotional idea in mind. Even though the benefits of spontaneous thought towards creativity and emotion are still debatable, it indeed helps people understand the intrinsic brain activity such as memory encoding and the decision-making proces [32].

4.1. Memory encoding

Episodic encoding memory is a long-term memory system for storing information. Research revealed that episodic encoding memory shared a link with mind wandering and spontaneous thought. For example, Blondé et al.'s research found a proportional relationship between the correct response of episodic memory and the number of reported minds wandering [1]. They further concluded that near medium-level mind wandering would most likely promote a "recollection-based recognition," meaning participants would not be distracted by spontaneous thought or their environment. Thus, spontaneous thought can involve and improve episodic encoding memory in a complex environment [1].

4.2. Decision making

Dijksterhuis and Strick proved that unconscious thought was beneficial in making complex decisions [7]. In their experiments, participants were asked to decide which alternative most attracted them, and they could also decide if they wanted to do a distracting game before making the decision. The results suggested that subjects who played distracting games generated more positive spontaneous thoughts and made a better choice. It also meant that the deliberate-thinking group who refused to play the game would have an inferior capacity to make a "correct" decision. A psychological test further supported this conclusion, which indicated that the mental representation of alternatives varied as

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people played the distracting game. These variations would further direct mental representations to be clearer and better organized, leading to a better decision [7].

In addition, spontaneous thought has a role in making a future decision. Studies stated that most spontaneous thoughts were prospective [5], and self-related spontaneous thoughts were more frequently focused on the future than the present and past [4, 6]. It means that spontaneous thought will combine the consideration of past concerns with future-directed thinking [4] and guided by motivations [30]. Spontaneous thoughts with future-oriented features will have different formats (i.e., abstract or detailed style) and contents [13]. He et al. suggested that near-future thoughts were more frequently planned than far-future thoughts [11]. With these results, the function of the prospective nature of spontaneous thoughts could be detected: spontaneous thought is capable of anticipating and planning future actions.

Spontaneous thought might facilitate decision-making in several ways. First, spontaneous thought can unconsciously connect to a topic with a broader thinking scale, helping people obtain various possibilities from the brain. Second, spontaneous thoughts help represent a more precise and organized picture towards correct decisions in a pressured environment. Third, spontaneous thoughts during sleep promote memory consolidation, so the reconsolidation process further helps people integrate new information and make better decisions.

5. Conclusion

Spontaneous thought does not equal useless ideas but is an important cognitive process in the brain. The undeniable fact shows that humans spend more than a third of their lives in spontaneous thinking or mind-wandering since they play an essential role in memory encoding and decision making.

It is also crucial that the research involving spontaneous thoughts be expanded in the future. A considerable amount of literature proves that conscious and goal-directed thoughts have significant impacts on humans' perceptual cognition, the intention of actions, and anticipatory abilities. However, spontaneous thought still lacks a detailed picture of its role and benefits. Although a few areas have been investigated, the neuronal region that produces spontaneous thoughts is broad. So the research gap of spontaneous thought still presents, but with future research and experimentations, we can slowly begin to understand the benefit and role of spontaneous thoughts in human cognition.

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