

Attention Network Testing, Creative Thinking and Mozart effect

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Contributor: Shulan Yu, Xinran Chen

Research indicates that music can influence human cognitive functions. Diverse musical settings can affect alertness, orientation, and executive control of attention in various populations.

Keywords: designers ; creativity ; music

1. Attention and Attention Network Testing

Attention permeates nearly all facets of human behavior. Thus, it has a prominent position in cognitive psychology. Attention aids in prioritizing information processing and in generating or retaining information without external input, which is crucial for processing working memory (WM) ^[1]. Working memory is strongly linked to attention, and workers' sustained attention and the nature of their activity impact their working memory ^[2]. This leads to sustained attention, which refers to the ability to actively analyze recurrent stimuli without being distracted by other stimuli that might cause habituation ^{[3][4]}. This ability is crucial and frequently utilized for advanced cognitive functioning in many everyday life and professional tasks. Attention can be categorized into three types: focused attention, selective attention, and broad attention. Focused attention involves identifying and responding to task-related information. Selective attention entails making positive choices and responding to task-relevant information while ignoring distracting external stimuli. Broad attention involves giving feedback and responding to multiple tasks simultaneously ^[5].

Posner and Petersen categorized attention into three subsystems: alerting, orienting, and executive control ^[6]. Fan et al. quantified three attention subsystems using the Attention Network Test (ANT) to assess alerting, orienting, and executive attention ^[7]. The alerting network can achieve and maintain readiness to respond to environmental signals ^[8]. The orienting network directs attention to specific stimuli in the environment to prioritize objectives ^[9], while executive control manages interference and resolves conflicts ^[10]. Meanwhile, multiple studies have demonstrated that the alerting network inhibits executive control, the orienting network enhances executive control, and the alerting network regulates orienting effects ^{[11][12][13]}. The test system is commonly utilized for attention assessment in adolescents, the elderly, and patients ^{[14][15]}. For example, Bajjal et al. conducted a study where adolescents who had received centralized meditation training (CMT) for at least one year were asked to complete the ANT task. The study compared their results to those of a control group and found that CMT improved alerting and executive control subsystems but did not significantly enhance orienting ^[14]. Dovorany et al. conducted the ANT on cognitively healthy older individuals in various musical settings, revealing that both cheerful and melancholic music enhanced attention in older adults. Specifically, cheerful music improved alertness in the older age group, while melancholic music enhanced executive control ^[15].

Participants complete the Attention Network Test on a computer by performing a flanker task to determine if the central arrow points left or right. Their reaction times (RTs) are recorded to assess the three subsystems. The task can be classified into three types based on the direction of the arrows: congruent trials (all arrows point in the same direction), incongruent trials (center arrow points opposite to flanker arrows), and neutral trials (center arrow without flanker arrows). Prior to the initiation of the flanker task, participants receive several alert cues: directional cues indicating the flanker task's location or no cues, requiring participants to determine the flanker task's presentation location themselves ^[7]. McConnell and Shore analyzed how cueing and flanker conditions are interconnected in ANT experiments and discovered that the alerting, orienting, and executive control networks can collaborate to influence behavior, as indicated by the behavioral data collected from the ANT ^[16].

2. Creative Thinking

Designers are acknowledged for being an exceptionally creative cohort. Design is commonly acknowledged as a creative profession, with good designers being themselves creative people, so their work is frequently characterized as creative

[17]. A designer's role involves focusing on the form and function of the design goal. Form refers to creating unique and innovative objects, while function involves customizing the design to meet the user's requirements. Designers must use adaptable thinking to balance various design criteria that impact originality and suitability [18][19]. Creativity is intricately linked to intellect, making its assessment thorough and intricate [20]. Questionnaire-based measures can be self-evaluated through personality inventories [21], thinking style inventories [22], and self-reported creative activities and accomplishments [23]. Task-based measures can be assessed by experts through divergent thinking (DT) tasks [24], artistic and real-life creative tasks [25], insight tasks [26], and so on. Many scholars in the field of creative thinking utilize a mix of scales and activities to evaluate the creative talents of the target group for a comprehensive assessment [18][27].

Creativity is intricately linked to attention. Existing research indicates a strong correlation between creativity and attention. Neurophysiological studies show that highly creative individuals tend to filter out fewer external stimuli, a phenomenon known as attentional leakage. This leakage allows individuals to focus on out-of-focus ideas and incorporate them into their current thought process, which can enhance creative thinking [28]. Several studies indicate that having a wide focus enhances creativity [29][30][31]. Creative high achievers spontaneously direct their attention to "seemingly irrelevant" sensory information in the environment within 50 ms of a sensory stimulus [32]. Unlike highly creative achievers, individuals with elevated levels of divergent thinking excel at screening out sensory stimuli considered "irrelevant" [28]. Zabelina et al.'s research confirms that divergent thinkers have a more flexible attention span, though tests measuring divergent thinking mostly emphasize concentration and inhibition rather than divergent thinking skills [33].

3. The Mozart Effect and the Arousal Hypothesis

The Mozart effect indicates that fast-tempo music in rhythmic and major modes can enhance arousal and well-being, but slow music in minor modes might reduce arousal and evoke feelings of melancholy [34][35]. Thompson et al. conducted a test to assess the effects of cheerful music (Mozart's sonata) and melancholic music (Albinoni adagio) on participants. The test results indicated that individuals who listened to cheerful music outperformed those who listened to melancholic music. Furthermore, participants who listened to cheerful music indicated that the music heightened their arousal and enjoyment [34]. Similarly, Xing et al. demonstrated experimentally that rhythmic structure plays a crucial role in the Mozart effect by studying the impact of Mozart K. 488 and its retrograde version on humans and rats. They found that the similarity between the music's melodic patterns and physiological cycles is what allows Mozart K. 448 to enhance mood and arousal across different species [36]. However, there is no unanimous agreement among academics on the Mozart effect. Within three years following the proposal, other scholars duplicated the experiment but did not discover the Mozart effect [37][38][39]. Several studies have shown that the Mozart effect is ineffective in children [40] and musicians [41] and does not improve epileptic patients [42] or enhance adults' situational memory [43]. Thus, the existence and reliability of the Mozart effect remain a subject of serious controversy.

In contrast to the Mozart effect, Husain contended that music's cognitive enhancements might be attributed to the "arousal of emotions" hypothesis [44]. Arousal and mood are distinct emotional reactions, but they exhibit some degree of correlation. Valence refers to the intensity of emotions, encompassing both positive emotions (joy, happiness, fondness, etc.) and negative emotions (sadness, anger, frustration, etc.) [45]. Arousal is the intensity of physiological or psychological activation [46]. In Russell's (1980) Circumplex Model of Affect, affect is represented by two orthogonal dimensions: arousal and valence [44]. Overall, the "arousal" hypothesis proposes that music affects cognitive functioning through emotional responses rather than directly improving cognitive emotional responses [45]. This contradicts the "Mozart effect" theory, which proposes that music enhances cognitive abilities in individuals. Nantes and Schellenberg's tests, which reproduced the "Mozart effect" by exposing subjects to Mozart's sonata plus a narrative plot, support the "arousal" hypothesis. The results indicated that individuals performed better on space mission tasks when exposed to the audio of their preferred stimulus. For instance, those who like Mozart's music demonstrated improved performance on the spatial tests after listening to the Mozart sonata, and vice versa. Mozart's music had no bearing on the participants' cognitive improvement; rather, it was the particular aural stimuli they subjectively chose that played a significant role in increasing their arousal levels and emotional responses [47]. Xia et al.'s experiments corroborated this hypothesis [48].

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