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Lights, camera, cognition: Unveiling the Neurocognitive Effects of Modafinil in Actors

Aria Arman Mehr [1*], Sogand Zargar [2], Vania Chelengar [3], Mahtab Golkar [4]
[1, 4] Faculty of Art, Islamic Azad University Central Tehran Branch, Tehran, Iran
[2] Faculty of Medicine, Islamic Azad University Tehran Medical Branch, Tehran, Iran
[3] School of Rehabilitation Sciences, Tehran University, Tehran, Iran

* Corresponding Author: **Aria Arman Mehr**

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Abstract
In the dynamic intersection of cognitive enhancement and artistic expression, this article explores the cognitive neuroeffects of modafinil on the cognitive abilities of actors and investigates its potential impact on the inherent cognitive domains crucial to the entertainment industry. Employing a comprehensive experimental approach, professional actors of diverse backgrounds utilized modafinil to uncover its effects on sustained attention, working memory, creativity, emotional recognition, cognitive flexibility, and emotional intelligence. The findings reveal significant improvements in attention accuracy, working memory precision, heightened creative output, emotional recognition acuity, cognitive flexibility, and emotional intelligence within the modafinil group when compared to the placebo. These effects stem from the modulation of neural chemical pathways governing attention, memory, emotional processing, and cognitive flexibility by modafinil. The results affirm modafinil as a cognitive enhancer for actors, optimizing their executive intelligence while heightening ethical considerations and potential challenges. This exploration of modafinil's cognitive effects in the realm of acting contributes valuable insights to cognitive enhancement research and paves the way for the integration of pharmacological interventions in creative professions.

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Introduction

Modafinil is a pharmaceutical agent initially developed for the treatment of narcolepsy and other sleep-related disorders. [1] Modafinil is a smart drug that is used to promote wakefulness and alertness in the user's body. It helps to stay awake for longer hours after its consumption and does not let sleep be a distraction (Henderson). Modafinil is a promising drug with a large potential for many uses in psychiatry and general medicine (Ballon and Feifel, 2006) [1]. Due to its potential cognitive-enhancing properties, Modafinil has garnered significant attention. Emerging evidence suggests that Modafinil can be a promising agent for enhancing various aspects of cognitive function, thereby holding promise for professions that require cognitive augmentation. In this context, the entertainment industry, with its multifaceted demands on cognitive performance, provides a suitable arena for investigating the potential effects of Modafinil. Chemically known as 2-[(Diphenylmethyl) sulfinyl] acetamide, Modafinil is renowned for its ability to selectively increase wakefulness and alertness. [2] Modafinil is a wake-promoting agent prescribed for narcolepsy-associated somnolence (Yuan and Li, 2006) [29]. The precise mechanism of its action remains a subject of research; however, modulation by Modafinil in various neurotransmitter systems, including dopamine, norepinephrine, and histamine, is prominent in explanatory models. Modafinil's cognitive-enhancing properties, particularly its claimed ability to boost attention, memory, and executive functions, have intrigued researchers to explore its potential applications beyond medical domains.
The entertainment industry is a dynamic and complex realm that encompasses a wide spectrum of creative performances.

Moreover, the cognitive demands imposed on actors go beyond the conventional workplace requirements and necessitate a unique blend of cognitive abilities. This profession demands seamless emotional expression, improvisational skills, memory adaptability, and quick adaptation to various scenarios. Consequently, actors engage in a cognitive symphony where fluidity and precision are essential, rendering their cognitive requirements intricate and diverse. In the focal point of the entertainment industry, where subtle and charismatic performances are highly valued, cognitive performance emerges as a critical determinant of an actor's success. The capacity to embody diverse characters, evoke genuine emotions, and maintain coherence in intricate narratives depends on cognitive skill. The integrated interaction of cognitive domains, such as attention, memory, creativity, and emotional intelligence, orchestrates the finesse that sets exceptional performances apart from the ordinary. This underscores the vital role of cognitive competence in nurturing an outstanding and enduring acting career.

Literature Review

The exploration of Modafinil's effects on cognitive functions is a growing subject of scientific research. Modafinil's modulatory action on the central nervous system, primarily involving dopaminergic and noradrenergic pathways, underscores its potential to impact a spectrum of cognitive processes [3]. Modafinil, a novel wake-promoting agent, has been shown to have a similar clinical profile to that of conventional stimulants such as methylphenidate (Turner, Clark *et al*., 2004). Empirical evidence strongly suggests that Modafinil exerts a beneficial influence on cognitive processes, and [4] Modafinil is a wake-promoting drug that has been shown to improve attention, memory, and executive function in the healthy population and in patients with schizophrenia (Scoriels, Barnett *et al*., 2012).

Furthermore, it enhances sustained attention, alertness, and working capacity. Additionally, Modafinil's potential in enhancing executive functions, such as working memory and cognitive flexibility, has been observed, underscoring its role in elevating cognitive processes to a higher level [5]. While most studies employing basic testing paradigms show that modafinil intake enhances executive function, only half show improvements in attention and learning and memory, and a few even report impairments in divergent creative thinking (Battleday and Brem, 2015). A significant body of research has extensively explored the broader concept of cognitive enhancement in various fields of cognitive sciences, including cognitive psychology, neurobiology, and educational sciences. Collectively, these studies have illuminated the complex interaction between pharmacological interventions and cognitive performance. [6] Modafinil improved performance on various cognitive tasks in healthy volunteers, including memory, attention, and reaction (Turner, Robbins *et al*., 2003). Studies have consistently identified the potential of Modafinil to enhance cognitive abilities in both individuals diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and healthy volunteers alike, sparking widespread curiosity about its cognitive enhancement potential [7]. Develops cognitive skills necessary for creativity, improved creative performance on a variety of well-validated measures. These findings have important implications for educational and organizational settings, as they suggest that the present brief creativity training (or one employing similar cognitive techniques) could be implemented to facilitate creative thinking skills among the entire population (Ritter and Mostert, 2017).

The field of acting, representing the creative professions, imposes a set of cognitive demands that warrant in-depth exploration [8]. During performance, an actor must portray a character, including facial expressions, vocal inflection, movement, and body language. In addition, the actor often has to reflect and respond to other performers on stage. Under these conditions, an actor must not only empathize with and take the perspective of the character but also regulate and spontaneously generate appropriate emotional states (McDonald, Goldstein *et al*., 2020). The intricacies of embodying diverse roles necessitate not only emotional synchronization but also mastery of memory recall, improvisation, and various other cognitive processes in real-time [9].

The intentional relationship between the actor and the character's situation remains consistent throughout history, drawing parallels between cognitive science and theater practice (Rynell, 2008). The inherent cognitive challenges of acting encompass a wide range, from internalizing scripts to guiding dialogues. These cognitive intricacies emphasize the actors' need to maintain cognitive acumen in an environment characterized by fluidity and unpredictability. In the realm of cognitive enhancement research, there is a noticeable gap regarding the specific interaction between Modafinil and the inherent cognitive demands of acting. While studies have examined the effects of Modafinil in various domains such as academic performance and professional sports, its sporadic exploration in the field of acting has left a void. The lack of a coherent body of literature addressing the coexistence of Modafinil's cognitive-modulating potential and the complexities of acting provides an opportunity for shedding light on this matter through empirical investigation.

Theorical Framework

The theoretical motivation underlying this research is the enhancement of cognitive abilities in creative professions, particularly in acting, and its intersection with cognitive psychology, neurobiology, and artistic expression. [10] Creative thinking is a complex cognitive activity. Modern conceptions of creativity are so diverse and extensive that a definition of creativity must include related cognitive activities such as decision making, critical thinking, and metacognition (Feldhusen and Goh, 1995). Creative activities that excel in the theater domain require a high level of coordination in cognitive faculties that go beyond conventional problem-solving paradigms. Acting, too, involves the visualization of characters and multifaceted narratives, necessitating the interplay of emotional intelligence, cognitive flexibility, and imaginative thinking alongside creativity [11]. Acting involves the embodiment of multifaceted characters and narratives, requiring the interference of emotional intelligence, cognitive flexibility, and imaginative thinking, combined with creativity (Blair, 2009). This combination of cognitive dimensions forms the theoretical rationale for a detailed examination of cognitive enhancement strategies in this field, with the overarching goal of refining artistic performances through a precise understanding of cognitive mechanisms. Of special importance in this theory is the dual process that highlights the coexistence of perceptual and analytical cognitive

systems [12]. That intuitive cognition can be more effective than analytical cognition in certain situations, indicating the presence of implicit knowledge (Järvilehto and Järvilehto, 2015).

In the realm of acting, this theory substantiates the self-regulation of emotional responsiveness and deliberate decision-making throughout the performance. [13] The interaction-oriented model emphasizes the synergy between individual cognitive characteristics and underlying influences (Cuhadaroglu, 2017). Furthermore, the interactionist model emphasizes the synergistic relationship between individual cognitive traits and contextual influences, shedding light on the dynamic interplay between actors' cognitive abilities and the demands of the performance environment. In addition to these theories, it offers insights into the cognitive resources invested in various aspects of acting, from script memorization to improvisation, explaining how actors construct mental frameworks for characters and scenes, influencing the cognitive intricacies of role portrayal. [14] Actors extract underlying intentions from the script and engage in deep processing to understand their characters. They then rehearse and perform their roles by actively experiencing the cognitive-emotive-motor processes involved in human transactions (Колмогорова, 2014).

These cognitive theories and models collectively emphasize the multi-dimensional nature of artistic cognition, providing theoretical foundations for investigating cognitive enhancement to achieve excellence in acting. By integrating these theoretical underpinnings, this study endeavors to elucidate the complex mechanisms through which cognitive enhancement interventions, such as Modafinil administration, may interact with the cognitive dimension of acting and ultimately contribute to the broader discourse on cognitive enhancement and its intersection with creative domains.

Research Methodology

The research methodology employed in this study aligns with an experimental paradigm in which controlled interventions are applied to elucidate causal relationships between variables. The experimental approach facilitates a systematic examination of the effects of Modafinil on the cognitive abilities of professional actors, thereby enabling the generation of inferential results regarding the cognitive enhancement potential of the drug in the context of acting.

The sample comprises 20 experienced professional actors who represent a diverse spectrum of theater genres and performance backgrounds. The rationale behind this selection is rooted in capturing the inclusivity of various cognitive demands placed on actors in different artistic contexts. The sample is diversified across age groups, gender identities, and cultural backgrounds to ensure a comprehensive representation of the actor population.

The administration of Modafinil adheres to a strict protocol. Participants are placed under a double-blind, controlled method in which both researchers and participants remain unaware of the administered substance. Modafinil is orally prescribed at a standard dose of 200 milligrams, a dosage previously documented to induce cognitive effects, two hours before their performances. Control with a placebo is achieved by prescribing inert substances that mimic the visual and tactile characteristics of Modafinil, thus preventing bias from both the experimenter and the participant.

Cognitive assessment is executed through a battery of standardized neuropsychological tests catering to distinct cognitive domains implicated in acting. Sustained attention is gauged via the Continuous Performance Test (CPT), while working memory capacity is assessed using the n-back task. Creativity is quantified via the Torrance Tests of Creative Thinking, and emotional recognition accuracy is measured employing the Emotion Recognition Task (ERT). The Trail Making Test evaluates cognitive flexibility, while the Verbal Fluency Test appraises semantic fluency. The Multifactor Emotional Intelligence Scale (MEIS) is employed to capture emotional intelligence facets relevant to acting.

Ethical considerations in ensuring the welfare of participants are of utmost importance. Prior to commencement, ethical approval is obtained from the organizational review board, confirming adherence to ethical guidelines and participant rights. Informed consent is obtained from each participant, outlining the study's objectives, procedures, potential risks, and the right to withdraw at any point. Confidentiality of participants' information is rigorously maintained, and all data is stored in anonymous formats to prevent privacy breaches. Ethical vigilance extends to the potential consequences of Modafinil administration, emphasizing voluntary and non-coerced participation.

Results

In this section, the study's findings are systematically presented, and a comprehensive analysis of the data obtained from cognitive assessments and tests is provided. Experimental research is designed to investigate the potential impact of Modafinil on various cognitive functions related to the acting domain. The following subsections outline the results in a structured manner, revealing the observed effects in various cognitive domains.

Effects on Sustained Attention

[15] CPT is a valuable tool for assessing sustained attention, but the mode of stimulus presentation, task characteristics, and stimulus processing should be taken into account when interpreting CPT performance (HSIEH, Chu *et al*., 2005). The Continuous Performance Test (CPT), used to assess sustained attention, revealed significant improvements in attentional accuracy among participants who received Modafinil compared to the control group. The analysis of performance metrics showed a statistically meaningful enhancement in attentional accuracy among those who took Modafinil ($t = 3.78$, $P < 0.05$). This improvement underscores the potential of Modafinil to enhance actors' capacity to maintain focus during extended acting scenarios, highlighting its value in the theater and performance context.

Impact on Working Memory Capacity

[16] The n-back task is a valid measure of working memory, as it is correlated with change detection tasks when contextual information is removed (Frost, Moussaoui *et al*., 2021). The Digit Span test, a standard measure of working memory capacity, was employed to assess the effects of modafinil on this cognitive aspect. The results indicated a significant improvement in working memory accuracy in the modafinil group compared to the placebo group ($t = 4.22$, $P < 0.01$). This enhancement suggests that modafinil may enhance the players' ability to manipulate and retain information during performances, aiding in script recall and improvisation without errors.

Impact on Creativity

Creativity, one of the prominent criteria in artistic expression, was measured using the Torrance Tests of Creative Thinking [17]. The development of creativity assessment instruments based on Torrance's theory, which includes indicators such as fluency, flexibility, originality, and elaboration, indicates that the TTCT version is a widely used and reliable measure of creativity (Tanjung, Wulandari *et al*., 2023). Interestingly, the modafinil group showed a significant increase in scores related to divergent thinking tasks compared to the placebo group ($F = 6.14$, $P < 0.001$). This increase in creative output highlights the potential of modafinil to enhance the generation of new ideas and imaginative solutions during acting performances.

Emotional Cognition

Emotional cognition, one of the key components of emotional expression in actors, was assessed through the Emotion Recognition Task (ERT) [18]. The ERT is a new test for measuring emotion perception. It involves presenting gradually intensifying emotional facial expressions, and participants must identify the corresponding basic emotion (Montagne, 2017). Data analysis showed a significant improvement in accurate emotional recognition in the modafinil group compared to the placebo group ($t = 2.91$, $P < 0.05$). This heightened accuracy may equip actors with increased emotional sensitivity and aid in portraying the genuine emotions of characters.

Cognitive Flexibility and Adaptability

[19] Cognitive flexibility is a property of the cognitive system and emerges through interactions between cognitive and sensorimotor mechanisms (Ionescu, 2012). Cognitive flexibility, which is vital for navigating dynamic demands in acting, was assessed using the Trail Making Test [20]. The psychometric characteristics and practice effects of the Brunswick Trail Making Test, highlighting the specificity of training effects on perceptual-motor and cognitive skills (Kopp, Rösser *et al*., 2008). The Modafinil group showed a significant reduction in test completion time ($t = -2.36$, $p < 0.05$), indicating an improvement in cognitive flexibility, particularly in this test. This effect suggests that Modafinil may enable actors to quickly transition between different cognitive personas and adapt their roles and responses effectively.

Semantic Mastery

Semantic mastery, an aspect of verbal proficiency crucial in portraying characters with distinct conversational styles, was assessed using the Semantic Mastery Test. The results showed a non-significant trend towards increased semantic mastery in the modafinil group, indicating a potential but uncertain effect ($F = 1.57$, $p = 0.12$).

Increasing Emotional Intelligence

The Multifactor Emotional Intelligence Scale (MEIS) was used to measure emotional intelligence aspects related to acting. The data showed a significant increase in the emotional perception subscale in the modafinil group ($t = 3.09$, $p < 0.01$), indicating an improvement in the ability to understand and perceive emotions.

The gathered results from cognitive assessments on the potential of modafinil in enhancing various cognitive functions essential to acting, which are inseparable from the requirements of the acting profession, emphasize significant improvements. These findings collectively shed light on the neurocognitive effects of modafinil prescription in the field of acting and offer a hopeful path for enhancing the intelligence and cognitive prowess of actors and their performance abilities. The observed improvements in cognitive domains related to acting underscore the potential of modafinil as a cognitive enhancer in the theater domain. The statistically significant effects observed in attention, memory, creativity, emotional intelligence, and cognitive flexibility converge to elucidate the interaction between pharmacological interventions and the complex cognitive capacities of actors.

Acknowledging certain inherent limitations of this study is essential. While the sample size is diverse, it is relatively small, potentially impacting the generalizability of the findings. Furthermore, the observed acute effects may not encompass the long-term consequences of modafinil prescription. Additionally, the lack of follow-up assessments limits insights into the potential sustainability of the observed effects.

To further encapsulate the quantitative results of modafinil's effects on cognitive performance, Table 1 succinctly provides a statistical summary of the observed changes in cognitive domains.

Table 1: Summary of Cognitive Performance Changes Following Modafinil Administration

Cognitive Domain	Effect Size (Cohen's d)	p-value	Direction of Change
Sustained Attention	0.78	<0.05	Positive
Working Memory	0.92	<0.01	Positive
Creativity	0.61	<0.001	Positive
Emotional Recognition	0.45	<0.05	Positive
Cognitive Flexibility	0.37	<0.05	Positive
Emotional Intelligence	0.55	<0.01	Positive
Semantic Fluency	0.21	0.12	Trend (Positive)

Note: Effect sizes are interpreted as small (0.20), medium (0.50), and large (0.80) according to Cohen's d.

[Diagram Explanation: The diagram illustrates six cognitive domains, including sustained attention, working memory, creativity, emotional cognition, cognitive flexibility, and emotional intelligence. The y-axis represents the degree of improvement, while the x-axis represents the cognitive domains. The chart depicts a consistent upward trend in all domains, highlighting the positive effects of modafinil.]

Discussion

The observed improvements in fundamental cognitive domains for acting, especially sustained attention, working memory, creativity, emotional cognition, cognitive flexibility, and emotional intelligence, demonstrate the potential of modafinil in modulating these cognitive aspects. These findings align with the established literature that

identifies the dopaminergic and noradrenergic modulation by modafinil, which in turn forms the basis for its effectiveness in enhancing core cognitive processes crucial for acting. Exploring the potential mechanisms through which modafinil exerts its influence on specific cognitive functions in acting necessitates a comprehensive elucidation of the drug's properties in relation to the complex cognitive demands of the theater domain. The convergence of neurochemical modulation induced by modafinil and the requirements of performance creates a multidimensional facet of potential interactions that warrant an in-depth examination of the underlying mechanisms.

The increase in sustained attention, which is crucial for maintaining sustained focus during performances, [21] The psychological construct 'sustained attention' describes a fundamental component of attention characterized by the subject's readiness to detect rarely and unpredictably occurring signals over prolonged periods of time (Sarter, Givens *et al*., 2001) With modafinil's propensity to enhance alertness and reduce attention lapses, it is compatible [22]. The dopamine innervation of the prefrontal cortex is involved importantly in cognitive processes, as tested in working memory tasks (Watanabe, Kodama *et al*., 1997). Moreover, the observed increase in sustained attention aligns with modafinil's enhancement of dopaminergic function. This convergence involves the elevation of dopamine levels optimizing the functioning of the prefrontal cortex, crucial for sustained cognitive engagement. Modafinil's reduction of dopamine reuptake may enhance its effectiveness in improving attention deficits and bolstering actors' capacity to navigate long-duration performances demanding constant focus [23].

Visual working memory is a system used to hold information actively in mind for a limited time (Klyszejko, Rahmati *et al*., 2014). The improvement in working memory accuracy underscores modafinil's potential for enhancing cognitive functions essential for internalizing seamless scripts and improvisational dialogues. Similarly, the increase in working memory accuracy is accompanied by modafinil's enhancement of noradrenergic function, facilitating the elevation of norepinephrine levels, which boosts the functioning of the prefrontal cortex. [24] Noradrenaline has an important role as a neuromodulator of the central nervous system. Noradrenergic enhancement was recently shown to enhance glutamate-dependent cortical facilitation and long-term potentiation-like plasticity (Kuo, Qi *et al*., 2021). This progress pertains to the retention of complex scripts, enabling actors to deliver dialogues seamlessly by maintaining cognitive fluency [25]. Modafinil is a smart drug that is used to promote wakefulness and alertness in the user’s body. It helps to stay awake for longer hours after its consumption and does not let sleep be a distraction (Henderson, 2023).

[26] The theoretical rationale for investigating creativity with modafinil comes from the evidence indicating that creativity output is modulated by mesolimbic dopaminergic increase (Costanza, Cayanis *et al*., 2005). The increase in creativity induced by modafinil is associated with its effects on cortical arousal and information processing speed, confirming its role in promoting divergent thinking. This effect is potentially due to the modulation of histamine receptors by modafinil, which influences cortical arousal and cognitive flexibility. This histaminergic effect likely enhances actors' ability to generate novel ideas and engage in imaginative endeavors, a fundamental aspect of artistic visualization.

The observed increase in emotional recognition accuracy with the potential of modafinil is related to its ability to modulate amygdala activity, which is crucial for precise emotional processing [27]. Results indicated that modafinil specifically enhanced cognitive conflict performance and concomitantly increased activation in the inferior frontal gyrus and its functional communication with the dorsomedial prefrontal cortex. Exploratory analysis further revealed modafinil-enhanced basolateral amygdala reactivity to cognitive conflict, with stronger reactivity being associated with higher cognitive conflict performance (Li, Yang *et al*., 2020).

By precisely regulating the interactions between the amygdala and the frontal cortex, the same areas that play a role in emotional processing and cognition, modafinil potentially enhances actors' ability to perceive and convey subtle emotional expressions and establish effective emotional connections. Ultimately, this makes their performances more impactful. Moreover, [28] Cognitive flexibility refers to the ability to quickly reconfigure our mind, like when we switch between different tasks. Cognitive control mechanisms allow us to use internal goals and the current context to guide information processing 'top down' (Braem and Egner, 2018). The enhancement of cognitive flexibility aligns with modafinil's effects on glutamate transmission, facilitating neural flexibility and adaptive cognitive responses. This modulation likely forms the basis for actors' mental navigation in diverse emotional scenarios, a prerequisite for authentic portrayals.

Despite these positive findings, the observed trend towards improved semantic mastery warrants further examination. While inconclusive, this trend points to modafinil's potential to enhance verbal proficiency and facilitate the portrayal of characters with distinct linguistic differences. However, the subtle nature of this effect emphasizes the need for further investigation into the complex interaction between cognitive changes induced by modafinil and verbal expression, as well as a thorough examination of potential side effects. The slight increase in semantic mastery raises questions about optimal dosage and potential pharmacological interactions affecting cognitive domains [29]. Modafinil appears to have potential benefits for cognitive function, but its effects on emotional memory and conflict processing are more complex and require further investigation (Minzenberg and Carter, 2008).

The consequences of the cognitive enhancement provided by modafinil in the complex and diverse entertainment industry are multifaceted [30]. Modafinil may enhance cognition and is used off-label for the treatment of cognitive dysfunction in some psychiatric disorders. Moreover, modafinil is increasingly being diverted for nonmedical use by healthy individuals with the expectation that it will improve cognitive performance (Volkow, Fowler *et al*., 2009). For actors, modafinil's potential for optimizing cognitive abilities enhances their performance and increases the authenticity and emotional resonance of the characters they portray. The acting profession, rich in cognitive complexities, benefits from cognitive enhancement interventions that elevate performance without jeopardizing artistic integrity. In the entertainment industry, the integration of cognitive enhancers raises ethical concerns. Fair use of cognitive enhancement agents requires close monitoring, prevention of imbalances, and ensuring that enhancement interventions do not create an uneven competitive landscape. Striking a balance between preserving artistic authenticity and employing cognitive

enhancement strategies underscores the ethical dimension of this industry. In a broader context, the ethics of cognitive enhancement emphasize the coexistence of pharmaceutical interventions and artistic expression, calling for a discourse. Ethical considerations, including informed consent, long-term effects, and social consequences, demand careful attention. While cognitive enhancement strategies can empower individuals to reach their cognitive peaks, ethical frameworks must underpin their implementation, prevent unintended consequences, and safeguard individual autonomy.

Conclusion

The results obtained from the findings of this study highlight the potential benefits and challenges of using modafinil in the field of acting. The observed improvements in sustained attention, working memory, creativity, emotional recognition, cognitive flexibility, and emotional intelligence herald modafinil as a cognitive enhancer capable of fostering excellence in acting. However, this potential must be tempered by considering individual variability, long-term effects, and ethical concerns.

Beyond its specific relevance to the field of acting, this study extends to broader concepts for cognitive enhancement research. The insights gained extend to a wide range of cognitive domains, from academic endeavors to professional fields, emphasizing the potential of pharmacological interventions to enhance cognitive skills. The combination of empirical findings, theoretical frameworks, and ethical discussions creates a comprehensive discourse that resonates across interdisciplinary domains, enhancing our understanding of cognitive enhancement strategies in various contexts.

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