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Personality correlates (BAS-BIS), self-perception of social ranking, and cortical (alpha frequency band) modulation in peer-group comparison

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HIGHLIGHTS

- BIS-BAS constructs modulate social ranking perception.
- Higher-BIS subjects were more responsive to decreased social ranking.
- Higher-BAS subjects were more responsive to increased social ranking.
- Prefrontal brain activity affects self-perception of ranking.
- Alpha band modulation and personality trait influenced the cognitive performance.

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ABSTRACT

The perception and interpretation of social hierarchies are a key part of our social life. In the present research we considered the activation of cortical areas, mainly the prefrontal cortex, related to social ranking perception in conjunction with some personality components (BAS – Behavioral Activation System – and BIS – Behavioral Inhibition System). In two experiments we manipulated the perceived superior/inferior status during a competitive cognitive task. Indeed, we created an explicit and strongly reinforced social hierarchy based on incidental rating in an attentional task. Specifically, a peer group comparison was undertaken and improved (Experiment 1) or decreased (Experiment 2) performance was artificially manipulated by the experimenter. For each experiment two groups were compared, based on a BAS and BIS dichotomy. Alpha band modulation in prefrontal cortex, behavioral measures (performance: error rate, ER; response times, RTs), and self-perceived ranking were considered. Repeated measures ANOVAs and regression analyses showed in Experiment 1 a significant improved cognitive performance (decreased ER and RTs) and higher self-perceived ranking in high-BAS participants. Moreover, their prefrontal activity was increased within the left side (alpha band decreasing). Conversely, in Experiment 2 a significant decreased cognitive performance (increased ER and RTs) and lower self-perceived ranking was observed in higher-BIS participants. Their prefrontal right activity was increased in comparison with higher BAS. The regression analyses confirmed the significant predictive role of alpha band modulation with respect of subjects' performance and self-perception of social ranking, differently for BAS/BIS components. The present results suggest that social status perception is directly modulated by cortical activity and personality correlates.

1. Introduction

The perception and interpretation of social hierarchies seem to be a key part of our social apparatus and have an evident impact upon our physical and psychological well-being. However, there had been little research aimed at identifying those brain areas and psychological factors involved in this high-order process, that is, the judgment of social hierarchies [35,37]. It is no surprise that in humans as well as other primates differential positions within social hierarchies are predictive of the individual's physical condition [1], mental well-being [2], neurocognitive functioning [33] and, in extreme cases, even survival [36]. In addition, the ability to infer accurately one's own status and the status of others in a social hierarchy is crucial to successful social interaction. Indeed, social hierarchies spontaneously and rapidly emerged in newly-formed groups of individuals, possibly because of the mutual agreement on inferences about others' competence and power [19,33].

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The quick emergence in social interactions is mirrored by its early appearance during ontogeny: two-year-old children are able to assemble stable, linearly transitive dominance hierarchies [11].

The pervasive impact of social status and dominance brought many researchers to examine the neurophysiological correlates of how social ranks are perceived, formed and maintained. However, only in the past few years have biopsychologists begun to explore how the brain processes information about social hierarchies (for a review, see Chiao [13]). Recent social neuroscience studies show that distinct neural systems are involved in the recognition and experience of social hierarchy, and that activity within these brain regions is modulated by individual and cultural factors. Levitan et al. [28] theorizes that a neural circuit linking limbic, prefrontal cortex, and striatal structures reflect the emotional, cognitive, and behavioral components of rank-related social interactions. Recent investigations examining the structure and function of brain areas associated with social rank offer preliminary support for this neural mechanism of a human social rank system. Dorsal and ventral portions of lateral prefrontal cortex – brain regions typically associated with regulating socioemotional responses and behavioral inhibition, respectively – are recruited during social status inference [14], particularly when people infer dominance in others from bodily postures [31,32] and symbols [42]. The engagement of DLPFC and VLPFC regions during the observation of dominant individuals probably reflects recruitment of brain regions that can exert top-down control over automatic processes, such as emotional responses to social hierarchy, to orchestrate a socially appropriate status response [31].

However, in our opinion, it is crucial to consider the implication of cortical areas, mainly the prefrontal cortex, which was shown to be activated in response to social ranking perception in conjunction with some specific subjective (self-perception of status) and personality components.

Indeed, on the one hand, the perception and interpretation of social hierarchies may be self-referential, relating to a person's own perceived position within them. In human beings, social hierarchies can be established along various dimensions: we can be ranked according to ability or skill, as well as economic, physical, and professional standing. Previous research suggested an important role for hierarchical rank in achieving accurate self-knowledge and self-improvement, particularly in the usage of upward social comparisons performance-related. This is the specific analysis of the social status in the context of performance-based feedback [42]. This direct comparison on a specific task may or may not improve our rank perception, taking into account the existing hierarchy. Moreover, it was also shown that social status perception affects performance on tasks that involve comparing our own performance with that of others [42]. In a previous experiment, Zink et al. [42] used fMRI to measure brain activation in participants presented with an interactive performance in which simulated players were manipulated to be either superior or inferior in task-related skills. The simulated players' statuses were held constant in a contrived "stable hierarchy" condition and allowed to vary periodically during a contrived "unstable hierarchy" condition. Results indicated that in a stable hierarchy, viewing a superior, relative to an inferior player activates bilateral occipital/parietal cortex, striatum, parahippocampal cortex, and dorsolateral prefrontal cortex. No unique activation associated with viewing an inferior player was identified.

On the other hand, the way that individuals judge such social ranking positions may partially depend on intrinsic personality factors such as the degree to which their own behavior is balanced between "approaching" in response to rewards and non-punishments (the Behavioral Activation System, BAS, [23]) and "withdrawing" from non-reward and punishments (the Behavioral Inhibition System, BIS) [17]. In one previous study it was found that subjects with a higher BAS were more likely to relate to the dominant character in a presented dyad, which was found to induce a positive effect, while those with a higher BIS were more inclined to relate to the submissive character, inducing a negative affect [16].

The BAS system should be responsible for both approach and active behaviors, and emotions associated with these behaviors generally induce the subject to approach to event/object that have generated the emotional response. The BAS is conceptualized as a motivational system that is sensitive to signals of reward, non-punishment, and that is important for engaging behavior toward a reward or away from a threat. Moreover, BAS has been associated with feelings of optimism, happiness, aggression and dominance [6,7,21,24]. Empirical evidence suggests that people with highly sensitive BAS may respond in great measure to positive, approach-related emotions, such as the expression of happiness and positive affect, that allow the subject to have a favorable and dominant behavior toward the environment [3–5,15,40]. Conversely, highly sensitive BIS people inhibit behavior in response to stimuli that are novel, innately feared, and conditioned to be aversive. The aversive motivational system is responsive to non-reward, avoiding to experience of negative or painful outcomes. Thus, the BIS is conceptualized as an attentional system that is sensitive to cues of punishment and non-reward, and that functions to interrupt ongoing behavior in order to facilitate the processing of these cues in preparation for a response. In the BIS framework "inhibition" refers to the abrogation of behavior in reaction to an expected or unexpected stimulus [20,41]. Gray also held that BIS functioning is responsible for the experience of negative feelings such as fear and anxiety in response to these cues [23,22].

Thus both our personality and our personal perception of social position and hierarchy may interact to impact our social success and sense of well-being. That is, self-perception of our position within the social ranking and our personality component related to reward mechanisms may influence the effective social relationship and the social ability to stay with other people.

Therefore, an integrative approach, combining both measures of self-perception and BIS/BAS mechanism, is needed in order to achieve a comprehensive understanding of the neurophysiological substrates implicated in hierarchy-related behaviors, mediated by the personality component of reward responsiveness. From the neuroanatomical point of view, the cortical correlates of the BIS/BAS system are the PFC, and left PFC was shown to be implicated in approach-related motivations and emotions, whereas the right PFC was found to be involved in withdrawal-related motivations and emotions [8,9]. Empirical data suggest that left and right frontal activity may reflect the strength of BAS and BIS activity respectively [6]. Due to the controlateral inhibition between the hemispheres, the lateralized approach and withdrawal or punishment-reward system are mutually inhibitory. The role of the reward system (BAS), on the one hand, and that of the frontal brain area, on the other, was supposed to be able to elucidate the dominance mechanisms. Thus, we may suppose that, based on the lateralized reward/punishment model, there are different contributions of the left and right hemispheres on self-perception of social ranking. It should be plausible that the hemispheric "competition" between the left and right sides would characterize social hierarchy behavior, showing a higher BAS reward attitude in "dominance conditions" with an imbalance in favor of the left hemisphere.

Reward system effect (BIS/BAS), social hierarchy perception as a function of subjects' personal performance in comparison with others' performance, and cortical responsiveness, were not previously evaluated together in detail. The effect of BIS/BAS on social ranking perception and the impact of this personality component on the frontal brain network were tested in the present research. The BIS/BAS component was considered a key factor in explaining the relationship between subjects' cognitive performance and self-perception of social status. The BIS/BAS construct was also considered an explicative factor, one able to explain the frontal brain contribution in social status representation. That is, the brain responsiveness was examined in relationship with the BIS/BAS dichotomy and the self-perceived status hierarchy status based on performance rating.

To study the effect of ranking related to the subject's performance we modified the superior/inferior status during a competitive task.