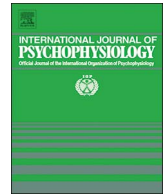




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## Event-related potentials during individual, cooperative, and competitive task performance differ in subjects with analytic vs. holistic thinking

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## ABSTRACT

It has been presented that Western cultures (USA, Western Europe) are mostly characterized by competitive forms of social interaction, whereas Eastern cultures (Japan, China, Russia) are mostly characterized by cooperative forms. It has also been stated that thinking in Eastern countries is predominantly holistic and in Western countries analytic. Based on this, we hypothesized that subjects with analytic vs. holistic thinking styles show differences in decision making in different types of social interaction conditions. We investigated behavioural and brain-activity differences between subjects with analytic and holistic thinking during a choice reaction time (ChRT) task, wherein the subjects either cooperated, competed (in pairs), or performed the task without interaction with other participants. Healthy Russian subjects ( $N = 78$ ) were divided into two groups based on having analytic or holistic thinking as determined with an established questionnaire. We measured reaction times as well as event-related brain potentials. There were significant differences between the interaction conditions in task performance between subjects with analytic and holistic thinking. Both behavioural performance and physiological measures exhibited higher variance in holistic than in analytic subjects. Differences in amplitude and P300 latency suggest that decision making was easier for the holistic subjects in the cooperation condition, in contrast to analytic subjects for whom decision making based on these measures seemed to be easier in the competition condition. The P300 amplitude was higher in the individual condition as compared with the collective conditions. Overall, our results support the notion that the brains of analytic and holistic subjects work differently in different types of social interaction conditions.

## 1. Introduction

Humans differ with respect to their preferred mode of perception, thinking, and problem solving along a holistic to analytic dimension. The key feature of individuals with holistic thinking is a propensity to evaluate events and objects in the context in which they are presented. Holistic subject view the world as a complex structure of interactions, relationships and trade-offs, and pay attention to links between events. Analytic individuals, to the contrary, tend to consider events and objects as invariant in time, primarily changing according to their own rules, rather than due to interaction with the environment (Nisbett, 2003). Nisbett et al., 2001 selected four domains as constructs of the analytic-holistic thinking: locus of attention (inclusion or ignorance of a context), causal attribution (account of situational causes or dispositionism), perception of change (cyclic or linear), and attitude toward contradictions (compromised middle ground between components of the whole or formal logic without compromises). The differentiation to holistic and analytic subject can be traced back to history in philosophy. Aristotelian

logic serves as an example of analytic, and Confucianism of holistic, thinking (Nisbett, 2003). Cultural differences between the analytic and holistic thinking styles are presently studied intensively (Kitayama and Uskul, 2011; Talhem et al., 2014; Nisbett and Miyamoto, 2005; Henrich et al., 2010).

Analytic-holistic thinking styles are assessed with either questionnaires or various experimental approaches (Norenzayan et al., 2002) where analytic individuals use clear pre-set criteria, while holistic individuals classify objects on the basis of their general similarity. Previous studies of the thinking styles have focused mostly on cross-cultural differences. For example, participants in South-East Asia were characterized by higher degree of holistic thinking than subjects in USA or Western Europe (Henrich et al., 2010; Norenzayan and Nisbett, 2000). However, the thinking styles have been shown to vary within cultures as a function of, e.g. professional activity, area of residence, and social class (Apanovich et al., 2014; Grossmann and Varnum, 2010; Henrich et al., 2010; Talhem et al., 2014).

Analytic and holistic thinking styles have been examined in both

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psychological and cognitive psychological cross-cultural studies (Pask, 1976; Davies and Graff, 2006; Gutchess et al., 2010). However, methods that are effective in cross-cultural comparisons are not always successful in distinguishing the analytic and holistic thinking styles of individuals within the same culture (Na et al., 2010). The Analytic-Holistic Scale (AHS) is a questionnaire that measures analytic-holistic thinking based on a four component model (Nisbett et al., 2001). The AHS can be used to measure both cross-cultural and within-cultural differences (Choi et al., 2007). It is worth noting that the phenomena studied in cross-cultural experimental designs can be influenced by a variety of other differences between the cultures. In our research we study analytic/holistic thinking inside one culture.

Cooperation and competition exist in all cultures with different degrees of manifestation (Basabe and Ros, 2005). It has been documented that competition occurs in different forms in collectivistic and individualistic cultures (Fülöp, 2009). The proportion of competitive and cooperative forms of social interactions in individualistic and collectivistic cultures is still an open question. It has been noted that combinations of individualistic and collectivistic tendencies exist in all cultures (Green et al., 2005). Based on extensive analyses of empirical and theoretical publications, Alexandrov and Kirdina (2013) suggested that analytic and holistic thinking should be addressed across different forms of social interactions, linking these thinking styles to the institutionality of a given society. Drawing parallels between these two thinking styles, the authors distinguished two types of “institutional matrices” based on commonality/non-commonality of material and technological environment: X-type, which dominates in Asia and Latin America, as well as in Russia, and Y-type, which dominates mainly in Europe and North America. The X-matrix (paralleling holistic thinking) was characterized by a predominance of cooperative relations, collectivism, and communality (Kirdina, 2014). Conversely, the Y-matrix (paralleling analytic thinking) was characterized by a predominance of competitive relations, individualism, and non-communality (Alexandrov and Kirdina, 2013). Since cooperation and competition (which are evolutionarily old forms of interaction (Griffin et al., 2004)) are the key factors of formation, functioning, and differentiation of social communities (Durkheim, 1997; Kirdina, 2014), we hypothesized that competitive and cooperative relationships are the candidate social interaction forms associated with analytic and holistic thinking.

This point of view is supported by others' work that has, for example, highlighted Western and non-Western cultures as syndromes with specific characteristics, moreover, holistic thinking has been associated with collectivistic cultures, and analytic thinking with individualistic ones (Henrich et al., 2010). Talhem et al. (2014) compared personal traits in different Chinese regions and found that analytic/holistic thinking correspond to individualistic/collectivistic forms of manufacturing prevailing in a region (Talhem et al., 2014). Finally, Fu et al. (2009) showed that whereas competition during training cultivated analytic skills in students, cooperation cultivated holistic thinking.

The neural mechanisms underlying social interactions has been studied extensively (for a review see Hari et al., 2015; Rilling et al., 2002), including competitive-cooperative and individualistic-collective interactions (Kitayama and Uskul, 2011). In particular, it has been observed that neural mechanisms supporting the same behavior in individuals characterized by analytic and holistic thinking are different (Henrich et al., 2010). However, even though the association of analytic and holistic thinking with collectivism-individualism has been hypothesized (see, for example, Henrich et al., 2010; Spencer-Rodgers et al., 2010; Alexandrov and Kirdina, 2013), the brain mechanisms supporting competitive and cooperative behavior in individuals with analytic and holistic thinking remains unexplored.

The P300 component of event-related potential (ERP) is a positive-polarity response in scalp-recorded EEG time-locked to stimuli and peaking roughly at about 350 ms from onset of task-relevant stimuli

(Sutton et al., 1965). P300 has been considered to reflect active goal-directed processing of the stimulus. The systems-evolutionary approach (Shvyrkov, 1990; Alexandrov et al., 2000; Aleksandrov, 2015), building on the theory of functional systems (Anokhin, 1973), postulates that any goal-directed behavioural act is supported by the actualization (retrieval) of a set of functional systems formed during life, (i.e., neural representations of past experiences). Our previous studies demonstrated that P300 component of ERP is related to decision making in choice tasks (Bezdenzhnykh, 2013, 2014) involving a discrimination of two stimuli with a speeded response (e.g., pressing either one of two buttons). The P300 has been associated with organization of a system and interpreted as dynamic actualization of experienced-based processing during behaviors (Aleksandrov and Maksimova, 1985; Alexandrov et al., 2007). It is known that holistic and analytic subjects use different experienced-based behavioural strategies during the same problem solving (Choi et al., 2007; Norenzayan et al., 2002). On this basis it can be hypothesized that P300 differs between analytic and holistic subjects.

The purpose of the present study was to test two hypotheses linking individual differences in thinking, social context, and the mode of social interaction. First, we hypothesized that subjects with analytic and holistic thinking would exhibit differences in both task-performance and brain physiology as measured with P300 amplitude and latency. Second, we hypothesized that these group differences are moderated by social context, i.e., depend on whether subjects perform the task alone or in pairs with other subjects. We further hypothesized that group differences are moderated by the mode of social interaction (cooperation versus competition). We hypothesized that these differences can be caused by the number of neural systems related to different forms of social interaction and estimated by the amplitude of P300. We specifically hypothesized that subjects with holistic thinking within one culture make decisions faster when cooperating, whereas subjects with analytic thinking make decisions faster when competing.

## 2. Materials and methods

### 2.1. Participants

Data of 78 participants (37 males, 41 females, median age 20 years, mean 24.6 years) were included in the analysis, after exclusion of 12 participants because of artifacts. All participants were paid for their participation. Prior to participation, an informed consent was obtained from each participant. The experimental procedures were approved by the Ethics Committee of Federal State-Financed Institution, Institute of Psychology, Russian Academy of Sciences, Moscow. The subjects were further divided into two contrast-groups, holistic and analytic, by selecting 20 percentile of the most analytic and holistic subjects based on their AHS scores. The analytic contrast-group included all subjects with AHS score below the 20th percentile ( $N = 15$ ), and holistic contrast-group included all subjects with scores above the 80th percentile ( $N = 16$ ). Such division criteria was based on the assumption that the thinking-related difference between the groups will increase, or at least remain on the same level, when the groups are more different in terms of holistic-analytic thinking, despite the smaller sample size. Earlier we performed a pilot study with full groups and obtained the same results (Apanovich et al., 2016a, 2016b). We suggested that if as ample size is a half reduced, but a significance level is higher or unchanged, it additionally testifies about validity and shows that the used division based on this construct is fundamental for the studied forms of social interactions and conditions. Methods for contrast group selection for statistical analyses are described earlier (Furr and Bacharach, 2013; Anastasi and Urbina, 1997). Two contrast group division (and also two task division immanent for these two groups) was transferred from cross-cultural studies and implemented for the intra-cultural study based on the reasons supported in Introduction.

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