Activitas Nervosa Superior Rediviva Volume 56 No. 3–4 2014

ORIGINAL ARTICLE

Ambiversion as independent personality characteristic

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Submitted: 2014-11-23 *Accepted: 2014-12-08* *Published online: 2014-12-20*

Key words: **Ambiversion ; Event-related potentials ; EEG ; Extraversion ; Personality**

Act Nerv Super Rediviva 2014; **56**(3–4): 65–72 ANSR563414A02

Abstract

OBJECTIVES: The EEG studies of the personality trait extraversion rarely commented as the intermediate subgroup or the ambiversion. Since the majority of human population falls precisely into the aforementioned intermediate category, it is important to study it more extensively.

DESIGN: In this work we examined the influence of the individual personality characteristic ambiversion on sensorimotor and cognitive information processing by studying the auditory Event-Related Potentials (ERPs) of healthy volunteers in auditory mental and sensorimotor discrimination task conditions. The volunteers completed Eysenck Personality Questionnaire and were divided into introverts, ambiverts and extraverts. We compared the N1 and P3 amplitudes and latencies of ERP components between introvert, ambivert and extravert subgroups. For sensorimotor task series we calculated two response time parameters: the onset of response movement activity and the moment of maximal push force power. Mann-Whitney U-test was used for statistical analysis.

RESULTS: The ambivert N1 amplitude was enhanced compared to the same ERP components of the extravert and the introvert subgroups. Our results revealed increase of P3 amplitudes for extravert subgroup in all passive, sensorimotor and mental task conditions. The ambivert showed higher P3 amplitude in comparison with introverts and extraverts predominantly in mental task series. Our data revealed activation differences in sensory and cognitive information processing related to extraversion and the ERP analysis confirmed that the personality characteristic ambiversion influences the N1 and P3 amplitudes of ERP components.

CONCLUSION: This study confirms that ambiversion has its EEG reflection in the auditory ERP components and supports that ambiversion must not be neglected and should be researched further as independent personality characteristic compared to the relevant extremes.

Abbreviations:

Abbreviations: ERP - Event-Related Potential; PL - passive listening; BSMT - binary sensorimotor reaction task; CLT - counting the low tones; RLT - reacting to the low tones; OMA - onset of response movement activity; MPF - moment of maximal push force power; I - introvert subgroup, A – ambivert subgroup; E - extravert subgroup.

Introduction

Ambiverts are defined as people who are neither introverts nor extraverts, but are in the middle between the two extremes. They combine the qualities of the extremes and in certain cases may manifest introverted behavior, and in other cases may have more extraverted behavior (Cohen & Schmidt 1979). Unfortunately, ambiversion has rarely been studied. There is research data mostly for factors that determine higher or lower level of extraversion. These factors are sought in the social plane (Lucas & Fujita 2000; Spinhoven *et al* 2011), at genetic level (Eaves & Eysenck 1975; Wacker & Gatt 2010; Lukaszewski & Roney 2011), as well as at central nervous system level.

The linear model is used in scientific publications, i.e. it is expected that with the increase of points on the scale of extraversion a specific physiological parameter will increase or decrease proportionally. This applies in cases where correlation is used, or the volunteers are divided only into two subgroups. However, this approach does not allow identifying specific links between the ambiversion and measurable physiological parameters.

There are scientific reports for linear relationship between extraversion level and event-related potential (ERP) components. The ERP research showed positive relation between introversion and amplitudes of N1 (Buckingham 2002; Stahl & Rammsayer 2004; Philipova 2008) and P2 (Stelmack & Michaud-Achorn 1985) components. The extraverts expressed greater N2 amplitude after reward associated auditory stimuli, while the tones associated with loss where related to greater N2 amplitude for introverts (Bartussek *et al* 1993). Contradictory data wЀre reported for the cognitive P3 component. According to some researchers greater P3 amplitude was reported for extraverts (Gurrera *et al* 2001,2005; Beauducel *et al* 2006; Philipova 2008), for others the greater P3 was for introverts (Cahill & Polich 1992; Bartussek *et al* 1996), and some found no P3 amplitude difference (Ortiz & Maojo 1993; Lindín *et al* 2007). There is certain consent that the spontaneous EEG and phase-locked ERP differences related to extraversion depend on experimental conditions (Revelle *et al* 1980; Gale 1983; Kumari *et al* 2004; Gram *et al* 2005; Fink & Neubauer 2008; Philipova 2008).

The ambivert category calculated as ±1 standard deviation of the mean value (Cohen & Schmidt 1979; Dewaele & Pavlenko 2002; Luciano *et al* 2004) represents the major part of human population and a principle question arises of whether neurophysiological factors exist, which predispose a person for this ambiversion area. The linear approach of looking for introversion and extraversion differences could not answer this question. Moreover, in terms of external stimulation, introversion and extraversion may not be reciprocal. For instance, it has been demonstrated that extraverts respond more strongly to positive emotional stimuli (Depue & Collins 1999; Lucas *et al* 2000), but this does not mean that introverts respond more strongly to negative emotional stimuli. People with high level of neuroticism respond more strongly to negative emotional stimulation (Norris *et al* 2007).

There is scientific data, supporting the idea that ambiverts may be considered as a separate category (Cohen & Schmidt 1979; Robinson 1989; Luciano *et al* 2004). It was demonstrated that the risk of cognitive impairments was lower in the group with moderate extraversion level, i.e. ambiverts compared to introverts or those with high extraversion level (Crowe 2006). So the ambiverts fall in cognitive impairments low risk category and extraverts and introverts can be placed in a general higher risk category.

Only few researchers classified the intermediate subgroup or ambiverts and compared their EEG data with those of highly introvert and respectively extravert persons (Stelmack *et al* 1977; Stelmack & Michaud-Achorn 1985; Robinson 1989; Doucet & Stelmack 2000; Luciano *et al* 2004).

By using correlation or dividing the volunteers into two subgroups, only the linear relation between extraversion and the corresponding EEG activity features such as frequency band level or ERP components latency and amplitude can be found. The ambivert subgroup is spread between the extremes and is not well researched. This justifies the aim of this work: to examine the influence of the individual personality characteristic ambiversion (intermediate subgroup) on sensorimotor and cognitive information processing by studying the auditory event-related potentials in auditory discrimination task conditions.

Methods

<u>*Participants and procedure*</u>

Each volunteer signed a Volunteer Informed Consent before the beginning of scientific investigations. An electroencephalogram (band-pass filtered between 0.3–70 Hz) of 71 (34 male and 37 female), right-handed (Annett 1982) healthy volunteers was recorded from Fz, Cz, Pz, C3' and C4', using Ag/AgCl "Nihon-Kohden" electrodes in four auditory mental and sensorimotor task conditions. The records were monopolar with reference to both processi mastoidei, according to the system 10–20. The grounding electrode was placed in the middle of the forehead. The EEG record sampling rate was 1000 [Hz].

For stimulation we used four identical audio series. Each series was composed of 100 tones arranged in pseudo-randomized order of 50 low (800 [Hz]) and 50 high (1000 [Hz]) tones with an intensity of 60 dB, duration 50 [ms] and randomized interstimulus interval from 2.5 up to 3.5 [s].We changed the type of task by giving different instructions to participants as follows: *first series* (passive listening (PL)) – we instructed the volunteers to listen to the auditory tone series without any task or mental effort; *second series* (binary sensorimotor reaction task (BSMT)) – we instructed the volunteers to press a button of force transducer with their right or left index finger in response to low or high tones respectively. In this task condition we gave the instruction that it is desirable to respond as fast as possible but to avoid making mistakes; *third series* (counting the low tones (CLT)) – we instructed the participants to count the low tones; and at the end of the stimulation series we asked about the counted number of the low tones; *forth series* (reacting to the low tones (RLT)) – we instructed the volunteers to press a button of force transducer with their right index finger in response of low tones. In this task condition we gave the instruction that it is desirable to respond as fast as possible but to avoid making mistakes;

To avoid blinks and to reduce other eye-based artifacts, the EEG record was performed in eyes closed condition in all tasks.

After the EEG recording procedure the volunteers (mean age 29.7 with standard deviation 9.0) completed Eysenck Personality Questioner (EPQ) adapted for Bulgarian population (Paspalanov *et al* 1984). We used the standard deviation of EPQ extraversion scores as parameter for group subdivision (Dewaele & Pavlenko 2002; Luciano *et al* 2004). The extraversion scale mean score was 13.3 ± 3.7. The ambivert subgroup was defined by the extraversion scale mean score minus one standard deviation to mean score plus one standard deviation – 15 introverts (age 33.3±12.6; 8 female and 7 male): from 1 to 8, 43 ambiverts (age 28.7±9.1; 23 female and 20 male): from 9 to 16 and 13 extraverts (age 29.1±6.1; 6 female and 7 male): from 17 to 20 points.

Offline data processing:

For each experimental condition we collected 100 trials with length 2 [s] – 0.5 [s] before and 1.5 [s] after the stimulus presentation. In offline mode after the end of the experiment we visually inspected the records and for further analysis we left only the artifact free trials. The trials related to wrong reaction responses in second and fourth task conditions were also rejected. We averaged the Event-Related Potentials for each person, experimental condition, stimulus (high and low) and electrode position separately. The latencies and amplitudes of N1, P2, N2 and P3 ERP components were determined by researchers using computer software.

We compared the ERP component amplitudes and latencies between introvert (I), ambivert (A) and extravert (E) subgroups. For sensorimotor (BSMT and RLT) series we calculated two response time parameters: the onset of response movement activity (OMA) and the moment of maximal push force power (MPF). Mann-Whitney U-test was used for statistical analysis.

Results

N1 amplitude

The analysis of the extraversion dimension revealed that the intermediate subgroup is characterized by greater N1 amplitude compared to introvert and extravert subgroups. This result reveals a quadratic trend of N1 amplitude to extraversion (Figure 1) and can be interpreted as enhanced sensory response to auditory stimulation of the ambivert subgroup. The differences are expressed mainly in frontal and central brain areas for both low (800 [Hz]) and high (1000 [Hz]) tone. The mean subgroup N1 amplitudes for all task conditions ranged from −14.5 to −5.8 [μV] for introverts, −16.0 to −8.3 [μV] for ambiverts and −13.1 to −5.8 [μV] for extraverts.

In passive listening task condition we found significantly larger N1 amplitude in the ambivert subgroup compared to introvert and extravert subgroups in Cz (A vs. I U=210, p=0.047; A vs. E U=152, p=0.013) and Pz (A vs. I U=211, p=0.049; A vs. E U=137, p=0.006) electrode positions for the low tone and in Cz (A vs. I U=151, p=0.005; A vs. E U=174, p=0.037) and C3' (A vs. I U=132, p=0.001; A vs. E U=161, p=0.019) electrode positions for the high tone.

In task condition with instruction to count the low (800 [Hz]) tones and to ignore the high (1000 [Hz]) tones we found significantly larger N1 amplitude in ambivert subgroup compared to introvert and extravert subgroups in frontal and central electrode positions (Fz (A vs. I U=167, p=0.012; A vs. E U=124, p=0.029), Cz (A vs. I U=154, p=0.006; A vs. E U=113.5, p=0.015), C3' (A vs. I U=137, p=0.002; A vs. E U=108, p=0.011) and C4' (A vs. I U=154.5, p=0.006; A vs. E U=115.5, p=0.017)for the low tone. For the high tone we found a similar differences in frontal and central electrode positions (Fz (A vs. I U=152, p=0.005; A vs. E U=131.5, p=0.044), Cz (A vs. I U=122, p=0.001; A vs. E U=121, p=0.024), C3' (A vs. I U=106.5, p=0.001; A vs. E U=111, p=0.013), C4' (A vs. I U=116, p=0.001; A vs. E U=130, p=0.040))

In binary sensorimotor task we found larger N1 mean amplitude in the ambivert subgroup compared to introvert and extravert subgroups but the differences were not significant.

In RLT task we found significantly larger N1 amplitude in the ambivert subgroup compared to introvert and extravert subgroups in Fz (A vs. I U=158, p=0.006; A vs. E U=153, p=0.010) and C3' (A vs. I U=133, p=0.001; A vs. E U=176.5, p=0.027) electrode positions for target tone and in all (Fz (A vs. I U=161, p=0.009; A vs. E U=105.5, p=0.009), Cz (A vs. I U=127.5, p=0.001; A vs. E U=119, p=0.021), Pz (A vs. I U=128, p=0.001; A vs. E U=114, p=0.019), C3' (A vs. I U=113, p=0.001; A vs. E U=120, p=0.023), C4' (A vs. I U=137.5, p=0.002; A vs. E U=127, p=0.034)) electrode positions for the non-target tone.

P3 amplitude

Graphical representations of P3 amplitude differences related to extraversion are shown on Figure 2.

Regardless of the instructions in the passive series, we observed the appearance of P3 in part of the inves-

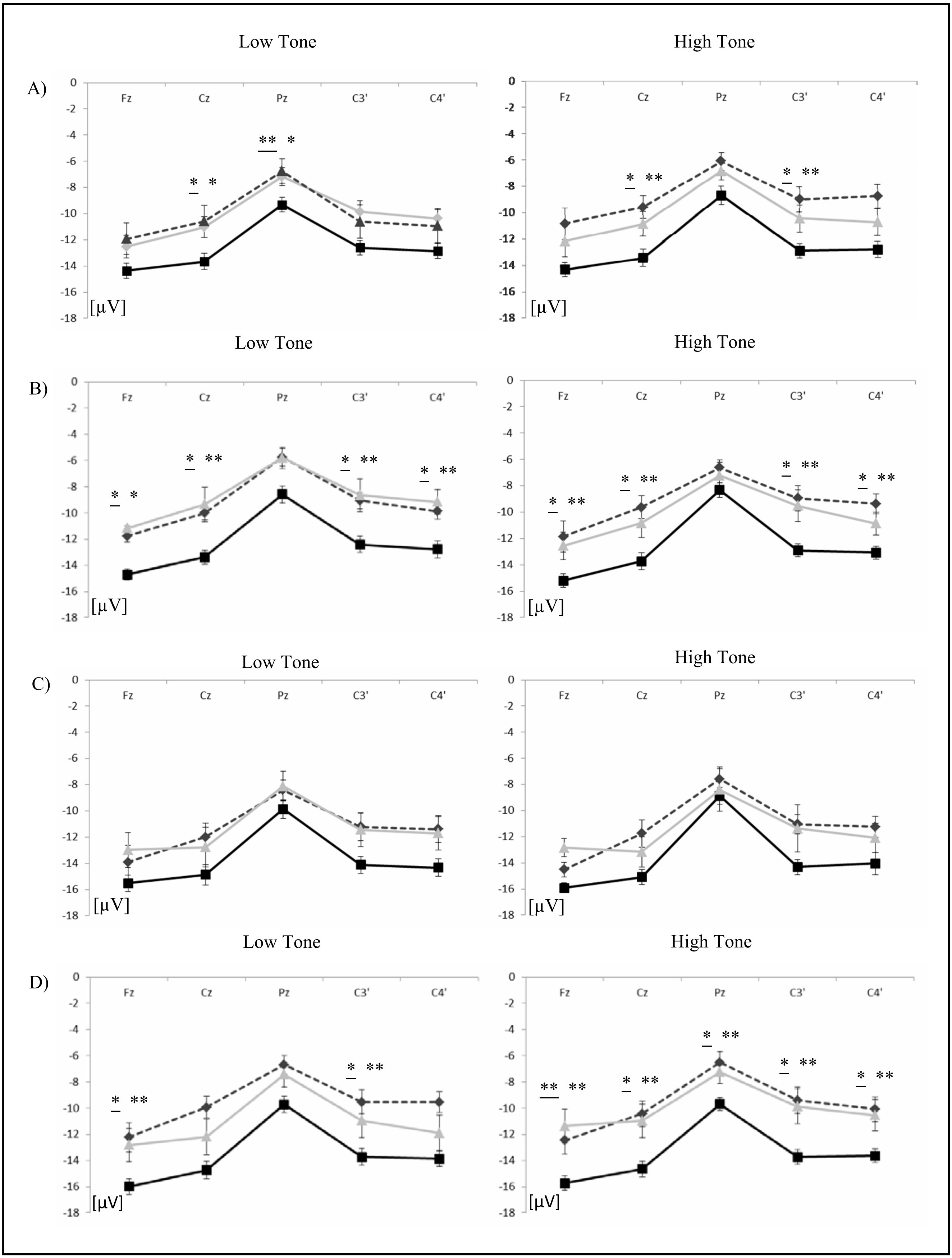

Fig. 1: Graphical representation of N1 ERP component amplitudes (mean and standard error) Introverts, Ambiverts and Extraverts in different task conditions. **A**) Passive listening task condition; **B**) Counting the low tone task condition; **C**) Mechanical response to low and high tones task condition; **D**) Mechanical response only to low tones task condition. Significance level for Ambiverts vs Introverts * – *p*<0.05; ** – *p*<0.01; Significance level for Ambiverts vs Extraverts * – *p*<0.05; ** *p*<0.01.

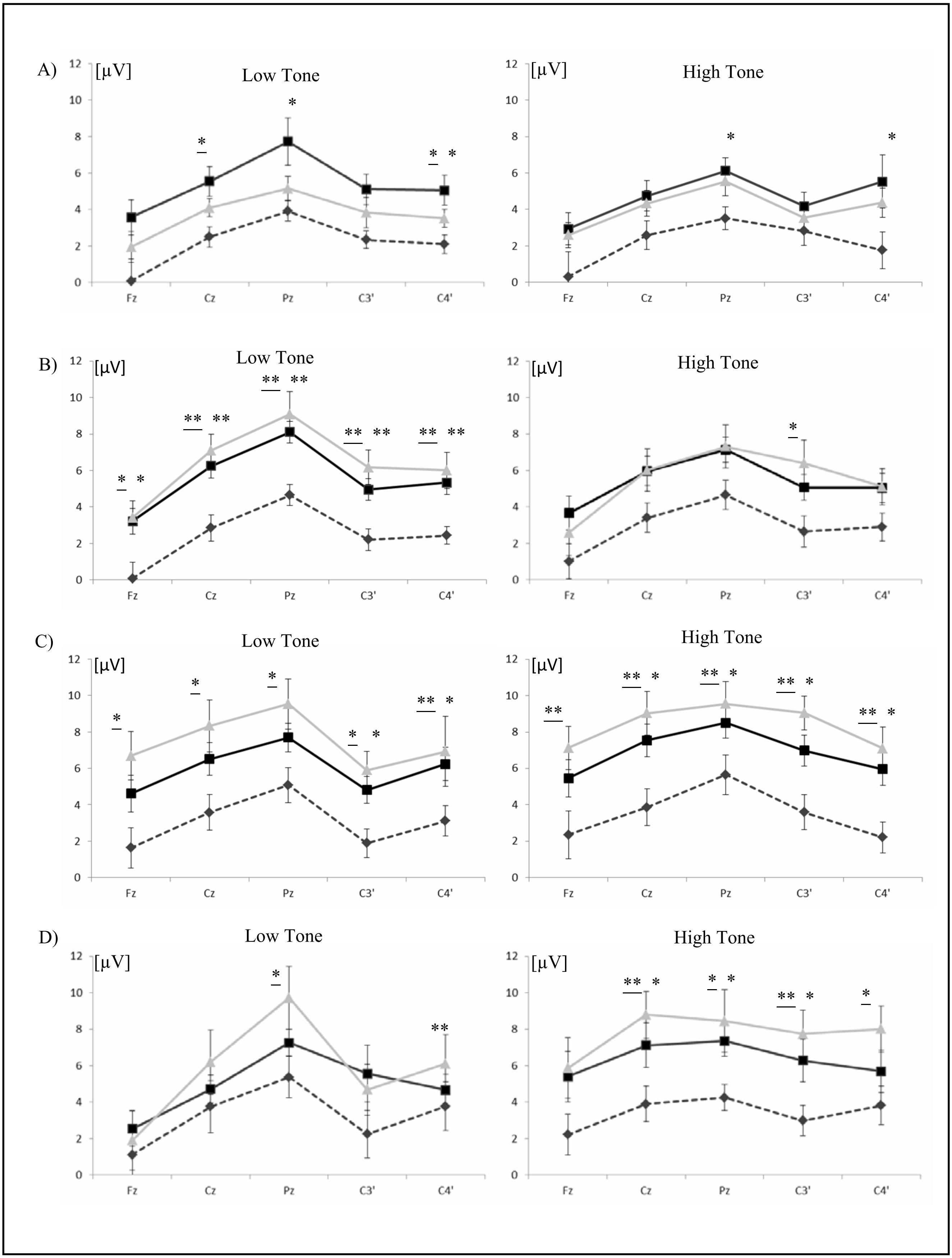

Fig. 2: Graphical representation of P3 ERP component amplitudes (mean and standard error) Introverts, Ambiverts and Extraverts in different task conditions. **A**) Passive listening task condition; **B**) Counting the low tone task condition; **C**) Mechanical response to low and high tones task condition; **D**) Mechanical response only to low tones task condition. Significance level for Introverts vs. Ambiverts * – *p*<0.05; ** – *p*<0.01; Significance level for Introverts vs. Extraverts <u>*</u> – *p*<0.05; <u>**</u> *p*<0.01.

tigated persons. In PL session 33% (5 from 15) for the high tone and 40% (6 from 15) for the low tone of introverts showed reliable P3 component amplitude. For the ambiverts this number was 67% (29 from 43) for the high tone and 62% (27 from 43) for the low tone. The highest percentage of reliable P3 component amplitudes was found in the extravert subgroup 77% (10 from 13) for the high tone and 69% (9 from 13) for the low tone.

In PL condition the P3 amplitude of the introvert subgroup was significantly reduced compared to extravert (Cz (U=7, p=0.018), C4' (U=10, p=0.026)) and ambivert (Pz (U=39, p=0.047), C4 (U=41, p=0.045)) subgroups for the low tone. In the same series the P3 amplitude of introverts for the high tone was significantly smaller compared to that of ambiverts (Pz (U=56, p=0.029), C4' (U=56,p=0.037)), but not in comparison to extraverts (Figure 2A).

In the mental task condition with "counting the low tons and ignoring the high tones" instruction the P3 amplitude of ambiverts was significantly higher compared to those of introverts (Fz (U=172.5, p=0.021), Cz (U=144, p=0.004), Pz (U=124.5, p=0.001), C3' (U=150.5, p=0.006), C4' (U=151.5, p=0.007). The P3 of introverts was smaller in comparison with the extraverts (Fz (U=38, p=0.022), Cz (U=20, p=0.001), Pz (U=24, p=0.003), C3' (U=24, p=0.003), C4' (U=26, p=0.004)) for the low tone (Figure 2B). For the high (non-target) tone the P3 amplitude in extraverts was significantly greater compared to that of introverts only in C3' (U=38, p=0.022) electrode position.

In BSMT the P3 amplitude was smallest for introverts and largest for the extraverts (Figure 2C). The P3 amplitude of introverts was significantly smaller compared to those of ambiverts (C3' (U=177, p=0.021), C4' (U=182.5, p=0.027)) and extraverts (Fz (U=34, p=0.013), Cz (U=38, p=0.022), Pz (U=36, p=0.027), C3' (U=34, p=0.013), C4' (U=23, p=0.002)) for the low tone and those of ambiverts (Cz (U=172.5, p=0.018), Pz (U=170.5, p=0.016), C3' (U=181, p=0.027), C4' (U=138, p=0.010)) and extraverts (Fz (U=31, p=0.004), Cz (U=34, p=0.006), Pz (U=27, p=0.004), C3' (U=22, p=0.001), C4' (U=29, p=0.005)) for the high tone.

In RLT the P3 amplitude of extraverts was significantly greater compared to that of introverts in Pz (U=53, p=0.025) electrode position for the low (target) tone (Figure 2D).

For the high (non-target) tone the P3 amplitude of subgroup introverts was significantly smaller compared to those of ambiverts (Cz (U=169, p=0.046), Pz (U=172.5, p=0.021), C3' (U=186.5, p=0.042)) and extraverts (Cz (U=29, p=0.009), Pz (U=34, p=0.013), C3' (U=29, p=0.006), C4' (U=35, p=0.023)).

<u>Latencies</u>

According to the results of Mann-Whitney U test analysis there were no significant N1 and P3 latency differences between introvert, ambivert and extravert subgroups in all task sessions. The mean N1 latency results for all task conditions ranged from 113 to 123 [ms] for introverts, 113 to 119 [ms] for ambiverts and 110 to 121 [ms] for extraverts. The mean P3 latency results for all task conditions ranged from 337 to 358 [ms] for introverts, 328 to 440 [ms] for ambiverts and 316 to 363 [ms] for extraverts.

<u>Reaction time data</u>

The Mann-Whitney U test didn't reveal significant differences in response times (onset of movement activity and maximal push force moment) of introvert, ambivert and extravert subgroups. In BSMT condition the mean and standard deviation values of response time were: OMA 443±68 and MPF 682±151 for introverts, OMA 432±74 and MPF 687±178 for ambiverts and OMA 435±83 and MPF 667±170 for extraverts for the high tone and OMA 448±70 and MPF 702±153 for introverts, OMA 436±67 and MPF 687±152 for ambiverts and OMA 446±79 and MPF 650±152 for extraverts for the low tone. In RLT condition the mean response time for the target tone was: OMA 430±86 and MPF 672±103 for introverts, OMA 447±73 and MPF 674±144 for ambiverts and OMA 433±98 and MPF 665±135 for extraverts.

Discussion

The goal of this paper is to examine the influence of the individual personality characteristic ambiversion on sensorimotor and cognitive information processing by studying the auditory event-related potentials in discrimination task conditions. Our data confirm the differences of brain activation processes between ambiverts, extraverts and introverts in condition of passive listening, mental and sensorimotor tasks The three subgroups division of extraversion scale allows us to obtain additional data associated with sensorimotor and cognitive information processing related to this personality characteristic. This subdivision makes it possible to find out not only "linear" but also "quadratic" interaction between ERP components and extraversion dimension. This study confirms that the individual personality characteristic ambiversion influences the EEG activity, in particular the amplitudes of ERP components. The ambivert subgroup showed greater N1 amplitude compared to introvert and extravert subgroups in all task conditions, but the differences were with higher significance (p<0.01) in mental task – CLT for both tones and in RLT for the high (non-target, where no button press was needed) tone.

The scientific literature data demonstrate that linear ERP differences related to extraversion also depend on experimental conditions and instructions (Gale 1983; Gram 2005; Fink & Neubauer 2008; Philipova 2008). We can expect that in other paradigms and stimulation intensities or modalities the ambiversion related ERP differences will increase, disappear or even show the opposite trend. Doucet and Stelmack (2000) using simple reaction time task found that introverts displayed larger N1 amplitudes than did ambiverts and extraverts. The result discrepancy with our results may be explained with different task instruction and respectively with different contribution of N1 component brain generators.

According to our results, good candidates for neurophysiological mechanisms related to ambivert–extreme dissociation are those who are involved in N1 auditory component generation. The N1 is generated mainly in primary and secondary auditory cortex (Knight *et al* 1980; Scherg & Cramon 1986; Woods *et al* 1987; Richer *et al* 1989; Eggermont & Ponton 2002). There are also N1 generators laterally situated in the associative cortex of the temporal and parietal cortex and in the motor and premotor area of frontal cortex (Näätänen & Picton 1987). It seems that early auditory information processing is critical for ambivert–extreme (introvert/extravert) behavior. Also, the activity in primary and secondary auditory cortex is modulated by attention (Bidet-Caulet *et al* 2007) and the N1 amplitude specifically can be modulated by selective attention (Kauramäki *et al* 2007). Thus the ambiversion related N1 amplitude enhancement can possibly be related to increased selective attention by ambiverts to auditory stimuli.

There was no significant N1 latency difference between introverts, ambiverts and extraverts, which indicates that there are not any differences in early sensory processing time between these subgroups.

The result for P3 amplitude enhancement in extraverts is in compliance with other authors (Gurrera *et al* 2001,2005; Beauducel *et al* 2006; Georgiev *et al* 2007; Philipova 2008). Stenberg (1994) reported that P3 amplitude enhanced with increasing degrees of extraversion. We found this enhancement to be valid in CLT, BSMT and RLT conditions. In PL task condition the extravert, as well as the ambiverts showed significantly larger P3 amplitude compared to introverts. One possible explanation is that extraverts and ambiverts are more inclined to self-instruction and that these volunteers may treat the unimportant stimuli as important ones and tries to deal with them, which is related to enhanced mental effort. In addition in a passive listening task condition introverts showed significantly lower P3 amplitude than ambiverts while P3 amplitude of extraverts was closer to ambiverts P3 value, but didn't differ significantly from either introverts or ambiverts P3 (see Figure 1A). The latter shows that we can't exclude the possibility that in conditions with different instruction type or different intensity or modality of stimulation other ERP components may be prone to quadratic interrelation with extraversion degree.

In conclusion the analysis of auditory ERP components in discrimination task conditions of ambiversion allows obtaining of additional data associated with sensorimotor and cognitive information processing according to the personality dimension extraversion. Our data revealed some differences in sensory and cognitive information processing of ambiverts compared to introverts and extraverts. This study confirms that ambiversion has its EEG reflection in the auditory ERP components amplitude and supports that ambiversion should not be neglected and should be researched further as independent personality characteristic compared to the relevant extremes.

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