NEUROPHYSIOLOGICAL BASIS OF THE COGNITIVE
GENDER DIFFERENCES IN ADULTHOOD IN HUMANS.
EVIDENCE FROM EVENT-RELATED BRAIN POTENTIALS

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Mini Review

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Abstract

Gender can affect nervous system functioning at multiple levels – from genetics to behaviour. In the present review, effects of gender on neurophysiologic mechanisms of mental rotation, efficiency of language processing, emotions and sensory processes were studied in adults by exploring event-related brain potentials (ERPs). Since these processes were best recognized as gender-dependent at the behavioural level, it was aimed to verify the presence of gender effects on the respective ERP correlates at the neurophysiologic level.

Articles from the PubMed database were selected, with a publication year until 2020. The review additionally includes studies that were cited in the selected articles. Thus, forty-six articles published between 1982 and 2020 were included. The reviewed data of healthy humans demonstrate that gender affects the early (related to perception and identification) and the late stages of processing (related to actual cognitive processes) of ERPs elicited during the three cognitive categories (mental rotation, language, and emotions).

Mental rotation process in males demonstrates smaller amplitudes and shorter latencies of ERP components. It is concluded that men perform mental rotation more efficiently than females because they not only apply a different processing strategy (implied by distinct topography patterns), but they also benefit from faster processing mechanisms.

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During *language processing*, gender differences are expressed in increased amplitudes, shortened latencies, and different scalp topographies of language-related ERPs in females compared to males. ERPs confirm that the two genders employ different processing strategies and provide new evidence that females' advantages can be associated with the fact that women are involved in a more extensive, more in-depth semantic processing and have a more automatized language processing.

Gender differences in the *emotion-related processes* are mainly expressed as increased ERP amplitudes in females compared to males for both the early and late ERP components. ERP results reveal that women are more sensitive to emotionally salient stimuli, especially to unpleasant negative ones, and that this sensitivity extends beyond early emotional reactivity to a later emotional and emotion-regulation processes.

However, studies exploring the neurophysiological level of the mental rotation process, language, and emotional processing in men and women are still scarce and inconsistent and thus further extensive research is required. The present review provides important hints that many of the established gender effects on specific processes (mental rotation, language and emotion regulation) may originate from fundamental and material-unspecific effects of gender on sensory processing mechanisms, which also merits additional clarification.

Key words: gender differences, ERP, mental rotation, language, emotions, healthy adults, review

Introduction. Gender can affect nervous system functioning at multiple levels – from genetics to behaviour [1,2]. Considering cognitive abilities in adulthood, males have most consistently demonstrated advantages in visual-spatial processing, especially in mental rotation [3–7], whereas females have been recognized for their advantages in language function [8,9] and emotional processing [10–14]. Although gender differences have also been found for perception in each sensory modality and subsequent cognitive processes [15,16], sensory processing, motor skills, processing speed, attention and memory are not unambiguously linked to one of the genders. Also in some cognitive sub-areas, the representatives of one gender are better presented, whereas in other sub-areas the representatives of the other gender are better presented.

To explain the variety and specificity of these differences, there has long been a “social versus biological” controversy, which is now gaining a great social and political significance worldwide. At the heart of this controversy is the scientific notion that human behaviour is formed by the interaction between biological and social influences [17]. The biological influence of gender on behaviour and related mental and cognitive processes is determined by genetically set brain morphology and physiology, the biological influence of hormones, including sex hormones, etc. Social effects are determined by individual development in a social context as well as cultural and economic factors, such as economic prosperity and gender equity, which affect females and males differently [18]. However, are gender differ-

ences in skills caused by the biology of gender factors, or by socially determined experiences and expectations? The difficulty in addressing this question stems from the fact that brain structural and functional architectures are created early in life cycle through continuous series of dynamic interactions between genetic influence and environmental conditions and experiences [19–21]. Brain has the capacity to form new synapses as a result of lifelong experience [22,23]. Therefore, even when gender differences in neuronal substrates are identified, it cannot be unambiguously known whether such differences are due to genetic gender-related (neuro) biological mechanisms, whether they represent a neuroplastic response to social environment, or they result from a combination of both biological and social effects.

Nevertheless, establishing gender effects at all related levels of neural substrate functioning is an important issue that would elucidate the origins of behavioural differences. The aim of the present review is to explore the effects of gender at the neurophysiologic level of organization of several faculties that have been most consistently recognized at the behavioural level as depending on gender. As described above, these refer to visual-spatial abilities, efficiency of verbal processing, emotional processes and perception. Confirming the effects of gender at the neurophysiologic (endophenotypic) level would highlight the origin of behavioural differences and might also serve to guide further research to fine-grained levels linked to genes and molecules. Here, event-related brain potentials were considered correlates of the neurophysiologic level of information processing.

A widely used method in psychological and clinical research for exploring the neurophysiologic mechanisms of mental processes is the method of event-related potentials (ERPs). It is non-invasive, with a good time resolution and relatively low costs. ERP is the averaged time-varying electroencephalographic (EEG) activity generated in response to an external or internal event [24–27]. The ERP contains positive and negative deviations called components, which are characterized by amplitude, latency and scalp distribution. ERP components most often appear within 1 to 3 s after stimulus and are conditionally categorized as exogenous (early, occurring up to 200–250 ms post stimulus and reflecting mainly the processing of physical stimulus characteristics) and endogenous (late, with a latency longer than 250 ms post stimulus, reflecting the processing of stimulus information content). ERP components are associated with a variety of cognitive and sensory processes [28,29]. In the present review, effects of gender on neurophysiologic mechanisms of mental rotation, efficiency of language processing, emotions and sensory processes were studied in adult humans by exploring ERPs. Since these processes are best recognized as gender-dependent at the behavioural level, it was aimed to verify the presence of gender effects on their ERP correlates.

Methodology. The articles used to prepare this review were extracted from the PubMed database (<https://pubmed.ncbi.nlm.nih.gov>), using the key words ‘gender differences’, ‘ERP’, ‘mental rotation’, ‘language’, ‘emotions’, ‘healthy

adults', 'review', and were published until 2020. The key words 'gender differences', 'ERP', 'mental rotation', 'language', 'emotions', 'healthy adults' were used to search for articles, related to gender differences in neurophysiological information processing (1053 articles found), and the key words 'gender differences', 'ERP', 'review' were used to search for review articles, related to gender differences in neurophysiological information processing (30 articles found). From the articles found by key words, only those that correspond to the topic, to the age ranges and written in English remain for further use. The review additionally includes articles that are cited in the articles, already selected for consideration. Thus, forty-six articles published between 1982 and 2020 are considered in the review, with nine articles published until 1999, 17 articles published from 2000 to 2009, and 20 articles – from 2010 to 2020.

Neurophysiological gender differences. *ERPs correlates of mental rotation.* *Overview of ERP correlates.* One of the largest gender differences is established for mental rotation [30]. ERP components elicited during mental rotation reflect several aspects of the mental rotation process: processing of sensory information (100–300 ms after stimulus onset), assessment of complex stimulus aspects and strategy selection (300–400 ms post stimulus, involving mainly frontal areas), rotation (400–800 ms post stimulus, centro-parietal areas), decision and motor response (approximately 700 ms after stimulus until the behavioural response, involving centro-parietal and frontal areas) [31]. However, most of the mental rotation ERP studies are concentrated on a particular post-stimulus time period and/or scalp area. They reveal a late, slow, and consistent increase in negativity with increasing angular disparity in the time window from approximately 350 to 800 ms over the centro-parietal scalp area that is considered a direct electrophysiological index of the rotation sub-process of the mental rotation and is named rotation related negativity (RRN) [31,32]. WIJERS et al. [33] have found that this slow negative ERP component is superimposed on the centro-parietal P300 ERP component. As a result, P300 becomes increasingly less positive when stimulus orientation deviates more.

Simple mental rotation – tasks with letters and figures. Among the extensive body of literature studying neurophysiological mental rotation correlates, very few ERP studies have investigated gender differences and the results are inconsistent [32]. DESROCHER et al. [31] have found no clear gender-related behavioural differences during the rotation of letters and abstract two-dimensional figures, but they have demonstrated higher P3 amplitudes (at Cz, 400–700 ms after stimulus onset) in women. The authors concluded that women might use more analytic strategies, including enhanced cortical involvement, compared to men.

Using a lowercase letter rotation task, GOOTJES et al. [34] have found the influence of gender on an early (130–400 ms) and a late (400–700 ms) ERP mental rotation effect. According to the authors, the early amplitude increase at midline electrodes in women suggests an effect at relatively early processing stages that

are probably related to perception and identification. The late rotation effect, which is thought to indicate the onset of the cognitive process of mental rotation, emerged earlier in men than in women. Moreover, men showed shorter response time to the task than women. These findings suggest that faster responses in men can be explained by the actual mental rotation taking place earlier. In addition, these authors have found increased involvement of the right hemisphere in men, probably pointing at a holistic strategy in males during mental rotation. BESTE et al. [35] have reported that gender has no effect on the mental rotation of characters with respect to neither performance nor ERPs. Arguing that characters are not the most reliable stimuli to study gender differences in mental rotation, PELLKOFER et al. [36] have used simultaneously presented polygons and have demonstrated differences in both performance (men outperform women on speed and accuracy) and functional brain asymmetry, with bilateral parietal brain activity in men and left-lateralized brain activity in women. Similarly, using a modified Shepard and Metzler task composed of sequentially presented three-dimensional figures, GRIKSIENE et al. [32] demonstrated that men performed the task more accurately than women, while there were no gender differences in response times. Women have higher global field power and an increased positivity over the parietal scalp area during the pre-rotational setup and the rotation-related period, indicating a greater cortical involvement. It is proposed that men perform mental rotation more efficiently as their accuracy is significantly higher, despite lower parietal ERP amplitudes and general brain activity (according to the concept of neural efficiency, see [37]). Men also have shown a higher left frontal activation. Although behavioural data have not supported the hypothesis about different strategies used by men and women, the differences in the brain activation topographies suggest that different brain sources are involved in both pre-rotational and rotation-related time windows.

Complex mental rotation tasks. No gender differences in both performance and P3 amplitude (250–600 ms) have been found in a complex mental rotation task (Spatial Folding and Cutting subtest of the Stanford-Binet IQ test), however, men have manifested shorter P3 and longer P1 (40–120 ms) latencies as well as lower N1 (120–220 ms) amplitudes than women [38]. The authors conclude that men devote more time to irrelevant information analysis, which results in mental rotation taking place earlier, and that even though men and women show similar performances on complex rotation tasks, they differ in their solution processes.

Chronometric mental rotation. Gender differences have been investigated during a chronometric mental rotation task with abstract and embodied figures (cube and human figures, and body postures, 17–26-year-olds) [39]. Gender effects have not been yielded for behaviour, but only for neurophysiological data. Specifically, there was a higher negative amplitude modulation at the frontal electrodes in females compared to males during the late (400–600 ms) time interval of all stimuli processing.

ERPs correlates of language processing. Overview of ERP correlates.

The ERP components that are related to language processing are the recognition potential (RP) and N400 [40–43]. In particular, RP is related to semantic processing [44–46]. It is an early positive peak appearing 200–250 ms after the delivery of a recognizable stimulus, such as a word or a picture. RP amplitude is larger for concrete vs. abstract, and for easy vs. difficult stimuli [47,48]. N400 is a late large negative component with peak latency within 250–500 ms and a centro-parietal maximum. It is considered an index of the difficulty of extracting stored conceptual knowledge related to the semantic meaning of a word, picture, etc. [42,49]. N400 amplitude is larger for difficult to understand stimuli. In addition, it increases during the integration of input information with previous knowledge [50].

Early semantic processing. When exploring gender differences in early semantic processing of three different categories of words – abstract, concrete neutral, and emotional, XU et al. [48] have found larger visual RP amplitude in females (college students). The results suggest that females are involved in a more in-depth semantic word processing.

While comparing words (presented as anagrams) in the visual modality with varying task difficulty (easy, medium, hard), females have consistently demonstrated a larger global field power than males and have displayed a different scalp field topography [51]. The differences in scalp distributions are considered to indicate activation of different neuronal assemblies in males and females during visual information processing. Effects have also been seen at short latencies in the order of 70–120 ms indicating differences in early visual stimuli selective processing.

Passive context processing. Gender differences have been found for N400 characteristics in 18–25-year-olds [52–54]. During visual processing of text in a passive context paradigm (22 participants, 22–29 years old) [52], a comparable influence of context on P1-N1 and no difference in topography between the two genders have been observed, which suggests that men and women encode semantic information in a similar way. However, gender differences in the latency and duration of N400 have been revealed, with women showing an earlier and longer lasting N400, suggesting that they engage in a more extensive semantic processing. The results show that genders differ in the controlled processing of meaning and, in consequence, in the use of the message content in passive word reading.

Semantic priming tasks. During performance of semantic priming paradigms, it has been demonstrated that N400 is larger and earlier in females (20 participants, 35–49 years old) [53]. These results support the idea of the existence of more automatic language processing in women. During an object recognition task, in which the subjects respond to relevant stimuli and do not respond to irrelevant and standard visual stimuli (30 participants, 18–25 years old) [54], females have demonstrated a larger N400 amplitude in response to both relevant and irrelevant stimuli. The larger N400 response to irrelevant stimuli is considered to represent the distinction between the irrelevant and relevant stimuli and the decision

not to respond to the irrelevant ones. The results demonstrate that female process semantic visual information differently, possibly by devoting more attention resources or by allocating more resources to distracting (irrelevant) stimuli.

ERPs correlates of emotional processing. *Overview of ERP correlates.* The late positive potential (LPP) is an ERP component that provides a neural measure of emotional processing [55]. It indexes sustained attention towards motivationally salient stimuli. The LPP is a centro-parietal relative positivity, starting about 200 ms after stimulus onset, which is evident throughout the duration of stimulus presentation. It is increased for emotional compared to neutral stimuli ranging from pictures, faces and words [56]. The positive component P300 also is related to the processing of emotional stimuli and is observed at frontal or parietal regions, 250–500 ms after stimulus appearance [57–59]. However, P300 is a complex correlate. It is modality-nonspecific and depends on cognitive processes, such as perceptual solutions, memory updating, attention, response suppression, and emotional arousal [60].

Emotional discrimination of faces. LEE et al. [61] (40 participants, 23–39 years old) have used a visual backward masking paradigm, in which the stimulus is either a fearful or a neutral face, appearing with varying duration (subthreshold, near-threshold, or suprathreshold), followed by a mask. Subjects perform a two-alternative forced-choice emotion discrimination task for each face. Women, as compared to men, have shown a significantly larger P100 amplitude in response to subthreshold fearful faces. Other researchers have found that N200 component is larger in women during viewing of unpleasant stimuli (28 participants, 21–35 years old) [62]. In an oddball paradigm, CAMPANELLA et al. [63] (20 participants, 20–27 years old) have demonstrated that N2b latency differentiated happy and fearful stimuli only in men. In another study [64] (32 participants), women have shown a larger P2 in response to unanticipated negative stimuli in a modified cue-target paradigm. These results imply that women have an attentive bias to emotional stimuli, particularly to unpleasant ones.

During facial drawings depicting sadness, no emotion, pleasure or anger, a greater auditory P300 amplitude in females has been demonstrated (26 participants, 22–56 years old) [65]. In that study, auditory ERPs were recorded using an oddball paradigm, while pictures and test tones were presented. Reduced P300 amplitude in males is supposed to be due to an inhibitory effect of attention for certain emotions. Enlarged women's P300 and LPP amplitudes have also been observed [66–69].

Emotional verbal processing. GASBARRI et al. [67] (48 participants, 23–33 years old) observed that women showed larger P300 responses and better memory retrieval for emotional verbal stimuli than men. Gender differences in an even later component, P450, have been observed in the study of OROZCO and EHLERS [70], in which women showed an overall longer latency and a larger amplitude in response to both happy and sad faces.

Emotional regulation performance. In a study of students' empathy for suffering people [71], ERPs have been recorded in response to stimuli with varying emotional intensity (highly and moderately negative and neutral patterns). Gender differences have been found in the parietal emotional response LPP to moderately negative stimuli. The results suggest that the well-known advantage of females in empathy can be explained by women's sensitivity to the emotional state of moderately suffering people. The results are commented in connection with the social role of women to raise offspring and mother's instinct to protect the child from any dangers, even when negative stimuli are not strong. Another explanation of these results is that females are more influenced by the environment.

Another study [72] (43 participants, 20 years old) has found gender differences in LPP during an emotion regulation task performance. Subjects were instructed to increase, decrease or maintain their emotional response while observing negative images. Females have demonstrated larger N1 and N2 amplitudes to negative stimuli, reflecting greater early emotional reactivity compared to males. LPP and P300 amplitudes were increased in response to 'increase' instruction, but women increased LPP amplitudes in a greater extent than men. These findings suggest that women are more sensitive to emotionally salient stimuli, and that this sensitivity extends beyond early emotional reactivity to a later emotional regulation process. The results confirm the assumption of women's propensity for negativity and suggest that women have a greater up-regulation of emotional responses to negative stimuli, which is associated with their vulnerability to fear disorders.

ERPs correlates of sensory processes. Sensory ERPs can be evoked by an external stimulus in any sensory modality and can be recorded by electrodes placed on the overlying sensory cortices. Early ERP components are related directly to stimulus-evoked sensory processing, and because their characteristics depend on the physical properties of the stimulus, they are called exogenous [73]. However, early ERP components may be additionally modulated by the amount of attention devoted to sensory stimulus, or by emotional and motivational biases. As detailed below, effects of gender on early ERPs have been found in both passive and attention/emotion processing conditions implying differences in sensory processes and/or early stages of stimulus selection according to task relevance in the main domains affected by gender at the behavioural level (visual spatial, language, and emotions).

Amplitude of early ERP components P1, N1. Gender differences have been observed for the amplitudes of early ERP components. Studies in visual and auditory modalities have shown that the P1 amplitude is larger in females, regardless of the level of attention [74, 75]. Gender differences in P1 component have also been reported during observation of children's faces, expressing different emotions (40 participants) [76], without observing gender differences in task processing speed. P1 amplitude increase in women is explained by the preference of females to the specific visual stimulus (children's faces).

P1N1 and N1P2 amplitudes from central leads have been found to be larger in females during passive listening [77]. The fronto-central P2 has been reported to be more positive and N2 to be less negative in women than in men when hearing mismatches are detected [78]. The authors support the hypothesis of gender dimorphic processing of new events.

Mismatch negativity. Gender differences have been reported for the mismatch negativity (MMN), a component that occurs in a latency range from 100 to 250 ms after changing the characteristics of the rarer stimulus from a series of stimuli. MMN registered in response to intensity changes of a pure tone [79] and when voice-emotional stimuli of social significance are recognized [80] has been found to be larger in females. During a passive auditory oddball paradigm where subjects listen to meaningless but emotionally spoken syllables “yes-yes” (pronounced neutrally, joyfully, or with fear), as well as to corresponding nonvocal sounds, MMN has also been higher in females, but only during listening to fearfully spoken syllables [81]. Larger emotional MMN amplitudes in females have been demonstrated during a working memory task, in which the position of the current visual stimulus is assessed and compared to that of one or two stimuli backwards [82], while at the same time, irrelevant stimuli are presented to the subjects – emotionally pronounced syllables “yes-yes” and acoustically matching non-vocal sounds. No gender effect on MMN has been demonstrated in response to nonvocal sounds. These results show gender differences in preattentive processing of emotional voice during performance of a task with different load. MMN has been found to be larger in males in the visual modality during a deviant-standard reverse oddball paradigm [83]. It has been shown that the change detection of visual stimuli is facilitated in males.

Latency of early ERP components. Gender differences have also been observed for the latencies of the early ERP components. Shorter females’ latencies have been reported during memory tasks for verbal stimuli or abstract figures recognition, which was accompanied by larger P2 amplitudes [84]. Shorter females’ P1 and N1 latencies have also been demonstrated during observation of children’s faces expressing different emotions (40 participants) [76], and a shorter P1 latency – during 40’ inverted visual stimulation (42 participants, 20–29 years old) [85]. Summarizing the results, a review article [86] reports about effects of gender on early auditory ERP latencies, but not on their amplitudes [77,87–90]. Shorter latencies of auditory ERPs in females are found for college students [91], young people [90,92–95], middle-aged [92,95], and even in the elderly persons [92]. The observed shorter early ERP latencies in women suggest that in the auditory modality, the speed of physical stimulus characteristics processing is higher in females than in males.

Summary and conclusions. The review of the literature examining the neurophysiological basis of mental rotation, language, and emotional processing, for which systematic gender differences have been established at the behavioural

level, demonstrates that gender also affects the ERP correlates of these processes.

Differences between males and females in mental rotation at the behavioural level are the largest and most consistently reported. They are traditionally thought to be due to differences in cognitive strategies between men and women [30]. Examining the neurophysiological basis of these differences in healthy adults demonstrates that gender effects on ERP correlates of mental rotation are found in the early (related to perception and identification) and in the late stages of processing (related to the actual process of mental rotation). In half of the studies, more accurate processing or shorter execution time in males is accompanied by specific changes in ERP components (smaller amplitudes, shorter latencies), or by specific topography patterns of brain activity. According to these neurophysiological results, males perform mental rotation more efficiently than females because they not only apply a different processing strategy as implied by distinct topography patterns, but they also benefit from faster processing mechanisms. Indeed, in the other part of the studies, it is shown that even though men and women manifest similar behavioural performance, they still differ in their neurophysiological processing mechanisms, and only one study does not find gender differences in either behaviour or ERPs. Although the disparate findings coming from the two levels of observation should be more thoroughly investigated [39], the assumptions about the use of different strategies by the two genders before and during mental rotation are generally supported by the neurophysiologic research. ERPs confirm the assumption that women use more analytical strategies with greater cortical involvement, and men probably use a holistic strategy. The present review indicates, however, that studies exploring the neurophysiological level of the mental rotation process in men and women are still scarce and inconsistent.

A more developed language function in females is suggested by their better results in solving most language tests at the behavioural level [5]. According to the present review, gender differences at the neurophysiological level are found in both the early and late stages of language processing. These differences are expressed as increased amplitudes and shortened latencies and as a different scalp topography (activation of different neuronal assemblies) of language-related ERPs in females compared to males. Thus, ERPs provide new evidence that female's advantage can be associated with the fact that women are involved in a more extensive, more in-depth semantic processing and involve more intensively automatic language processes. ERPs further confirm that the two genders employ different processing strategies since females appear to allocate more attention resources or devote a greater importance to distracting (irrelevant) stimuli. However, the influence of gender on the neural mechanisms of language processing is still insufficiently understood being investigated mainly in the visual modality, thus requiring further extensive research.

A number of studies highlight the advantage of females in some emotionally grounded social skills [96]. The present review demonstrates that at the neurophys-

iological level, gender differences are found both in the early emotional reactivity and in the emotion-related late cognitive processes. These gender differences are mainly expressed as increased amplitudes in females compared to males of both the early and late ERP correlates of emotions. ERP results shed light on the mechanisms of emotional processing in males and females and reveal that women are more sensitive to emotionally salient stimuli, especially to unpleasant negative ones, and that this sensitivity extends beyond early emotional reactivity engaging additionally later emotional and emotion-regulation processes. Yet, neurophysiological research of gender-dependent emotional processing is still scarce, conducted mainly in the visual modality, and requiring extensions for a detailed description of why and how women and men process differentially emotional information.

The present review provides important hints that many of the established gender effects on specific processes (mental rotation, language and emotion regulation) may originate from fundamental and material-unspecific effects of gender on sensory processing mechanisms. Indeed, according to the results, systematic gender differences are found in the early stages of stimulus processing associated with sensory processes [15,97]. Females versus males show increased amplitudes of the early exogenous ERP components in the auditory and visual modalities, indicating that they process physical stimulus characteristics with greater intensity. Larger amplitudes in women are explained by a greater sensitivity to stimulus change, preference for the presented stimulus, or greater commitment to certain information. Males show increased amplitudes of early ERP components only in the visual modality, which suggests a greater sensitivity to changes in visual stimulation. Further, shortened latencies of the early ERP components in women have been reported in a wide range of studies, mostly in the auditory and few in the visual modality, suggesting faster mechanisms of stimulus information processing in females compared to males. In the auditory modality, gender effects are explained by anatomical differences (in the head size, which is a measure of the neurological length of the auditory pathway, in the cochlea size and in the basilar membrane elasticity), with hormonal differences (connected with estrogen, which improves synaptic transmission and nerve conduction), differences in body temperature, etc. [86]. Considering the role of non-specific neurobiological factors for shaping fundamental sensory processes and modifying subsequent higher-order operations is certainly a focus of future research.

As discussed above, identifying gender effects at various levels of neural substrate functioning may help clarify the origin of behavioural gender differences. However, to disentangle neurobiological and social determinants of these differences, additional neurophysiological studies with a special design controlling the influence of psychosocial, cultural and educational factors and covering a wide age range – from childhood to adulthood – still need to be carried out.

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