Neural dynamics of social emotion processing in alexithymia

Wang, Zhihao

DOI:
10.33612/diss.232785415

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2022

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the “Taverne” license. More information can be found on the University of Groningen website: https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment.

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.
Chapter 1

General introduction
Chapter 1

This thesis focuses on the neural dynamics of social emotion processing in people with alexithymia. In this introduction (Chapter 1), I will i) introduce some basic concepts about alexithymia, ii) summarize the dominant emotion theories, iii) review neuroimaging findings regarding emotion processing in alexithymia, iv) clarify the definition and relevant findings of social emotions, and v) review previous literature on social emotion processing in alexithymia. Finally, I propose the main questions toward the processing of social emotion in alexithymia, as well as the aims of this thesis.

Alexithymia

Alexithymia (“no words for feelings”) is characterized by an impaired ability to identify, describe and regulate one’s feelings (Luminet et al., 2018). Substantial evidence has demonstrated that difficulties in emotion processing, which are more prominent for negative emotion, are at the core of alexithymia (Lane et al., 2000; Swart et al., 2009; van der Velde et al., 2013). Based on clinical observations, Nemiah & Sifneos, (1970) formulated the construct of alexithymia, including difficulties in i) identifying and describing feelings, ii) distinguishing between feelings and bodily sensations related to emotional arousal, iii) fantasizing, i.e., an individual’s inclination to imagine and daydream, and iv) an externally rather than internally oriented thinking style. Based on these theoretic constructs, two psychometric tools for alexithymia have been developed (for a review, see Preece et al., 2018). The 20-item Toronto Alexithymia Scale (TAS-20) consists of three factors: difficulty in identifying feelings (DIF), difficulty in describing feelings (DDF) and externally oriented thinking (EOT; Bagby et al., 1994). The BVAQ assesses two additional features of alexithymia—the affective factors of emotionalizing and fantasizing, which are not included in the TAS-20 (Vorst & Bermond, 2001). On basis of these five factors, the BVAQ also contains two high-order factors: a cognitive dimension and an affective dimension. These two
self-report scales have been most widely used to assess alexithymia in research settings over the past decades.

Accounting for 10% in the general population across western and eastern culture (Honkalampi et al., 2001; Kano et al., 2003; Zhu et al., 2007), alexithymia is thought to be a subclinical (i.e., on a continuum between healthy people and patients) personality trait (Luminet et al., 2018) and a transdiagnostic risk factor for various mental disorders. This holds for depression and anxiety (Hendryx et al., 1991; Li et al., 2015), autism spectrum disorder (ASD; Bird & Cook, 2013), substance abuse disorders (Cruise & Becerra, 2018), posttraumatic stress disorder (Frewen et al., 2006), somatic symptom disorders (Cerutti et al., 2020), eating disorders (Marsero et al., 2011), and psychotic disorders (van der Velde et al., 2015), amongst others. As an example, in one study approximately half of patients with ASD were shown to have high scores on alexithymia (G Bird & Cook, 2013). Moreover, alexithymia, rather than autism, accounted for socio-emotional processing difficulties in these patients with ASD (Cook et al., 2013). Alexithymia has also been shown to be negatively related to psychotherapeutic outcome (Ogrodniczuk et al., 2011) and improvements in alexithymia are positively associated with the clinical outcome (Zorzella et al., 2020). In the past decade, the Research Domain Criteria (RDoC) framework has been promoted to investigate mental health at the symptom level and underlying psychological and neurobiological mechanisms instead of the diagnosis level in the Diagnostic and Statistical Manual of Mental Disorders (DSM; Insel et al., 2010). Studying alexithymia as a possible contributing factor to psychopathology fits in this approach. Given the transdiagnostic nature of alexithymia, significant steps forward in alexithymia-related studies are essential for a better understanding of mental disorders.
Emotion theories

Emotion is fundamental for virtually all aspects of human behavior, because it prioritizes action (Blakemore & Vuilleumier, 2017; Frijda, 1986). The popular dimensional theory of emotion contends that emotion can be represented by a limited number of continuous dimensions, e.g., valence, arousal, and motivation (Barrett, 1998). Different from the dimensional theory of emotion, the discrete emotion theory regards each emotion category, e.g., fear and sadness, as the basic unit for emotion processing (Ekman, 1992). From the perspective of psychological operations underlying emotion, the locationist theory and the psychological constructionist theory have been proposed. The locationist theory holds that emotional states from different emotion categories cannot be decomposed into more basic psychological components that suggested to reside within particular gross anatomical locations in the brain. Lindquist et al., (2012) mention the approach by Panksepp, (2004) as an example. In contrast, the psychological constructionist theory proposes that all emotion categories emerge from a combination of basic mental operations, including core affect, executive attention, and emotion words (Lindquist et al., 2012). Specifically, core affect refers to the mental representation of affective signals from bodily sensations at the dimensional level, such as feelings of displeasure. Second, emotion words transform from emotional modalities (e.g., pictures or voice) to abstract categories for communication and experience. When faced with emotional pictures, voice or touch, our brain first transforms them into emotional words to make meaning of core affect. Finally, executive attention selectively facilitates specific mental representations and inhibits other psychological processes. This operation is crucial to integrate multiple operations (i.e., facilitation or inhibition) to produce an emotional “gestalt”. This constructionist approach may be relevant for studying alexithymia, given its emphasis on processing of emotion concepts (including linguistic categories and verbalization) in order for one to make sense of core affect and executive
attention. Importantly, based on the findings of functional magnetic resonance imaging (fMRI) studies, evidence from meta-analysis of activation and from multi-variable decoding approaches can be interpreted as being compatible with all above-mentioned emotion models in addition to the locationist theory (Hamann, 2012; Lindquist et al., 2012; Xu et al., 2021).

Benefiting from high temporal resolution electroencephalography (EEG), many studies have the potential to inform these emotion theories (e.g., the time course of emotion processing) and test hypotheses. With the event-related potentials (ERPs) technique, a rich literature using facial expressions as stimuli have shown neurocognitive mechanisms of emotion processing: early-stage components (e.g., N1) reflecting perceptive (automatic) processing and middle-stage ERPs (e.g., N2) representing further affective processing (Luo et al., 2010; Zhang et al., 2014; for a review, see Calvo & Nummenmaa, 2016), while late components (e.g., P3 and late-positive potential; LPP) indicating the impact of emotion on cognitive activities or decision-making, which is termed emotion-related downstream processing in this thesis (e.g., emotion-guided learning; for a review, see Hajcak et al., 2010). Combining spatial and temporal information, neuroscientists have proposed a temporal-spatial model of emotion processing in the brain (Adolphs, 2002). Moreover, time-frequency analysis, which can reveal dynamic brain oscillations, have shown emotion-related oscillations at theta and alpha bands (Gable et al., 2021; Segrave et al., 2012). The theta band has been broadly involved in subjective experience of emotion, specifically for valence encoding (Gable et al., 2021; Kamarajan et al., 2008). Regarding the alpha band, the classic theory of gating of inhibition (i.e., information is gated by inhibiting task-irrelevant regions) highlights the important role of alpha oscillations in attentional deployment (Jensen & Mazaheri, 2010). In addition, frontal alpha asymmetry (FAA) has been widely used in the field of affective neuroscience, indicating motivational (approach/withdrawal) processing (Harmon-Jones et al., 2010). In
sum, EEG studies have informed important neural timing and mechanisms underlying emotion processing.

**Alexithymia and the brain**

Neuroimaging studies have examined the neural origins of difficulties in emotion processing in alexithymia (for a review, see Goerlich, 2018). Meta-analysis of emotion processing differences in relation to alexithymia has identified key neural correlates of alexithymia in the amygdala, the dorsal anterior cingulate cortex (dACC), the dorsomedial prefrontal cortex (dmPFC) and the supplementary motor and premotor brain areas (van der Velde et al., 2013). Regarding structural neuroanatomical differences, previous studies consistently showed decreased gray matter volumes in insula, amygdala, orbital frontal cortex (OFC) and striatum in alexithymia (for a meta-analysis, see Xu et al., 2018). These brain areas are involved in multiple functions relevant to processing emotions. First, the supplementary motor and premotor brain areas are associated with the mirror neuron system (MNS; Molenberghs et al., 2009). Specifically, the involvement of motor-related brain regions was found during the observation, imitation and execution of motor actions (Carr et al., 2003; Molenberghs et al., 2009), suggesting the processing of initial emotion perception. Second, the insula, the amygdala and the dACC are key parts of the affective system, representing different aspects of affective encoding (Critchley et al., 2001; Xu et al., 2021). The insula and dACC have also been shown to be involved in emotion-related downstream processing, specifically in subjective emotional experience (insula) and emotional self-awareness as well as emotion-cognition integration (dACC; Botvinick et al., 2004; Gu et al., 2013; Y. Luo et al., 2014). Third, the dmPFC is involved in emotion regulation and social cognition (Amodio & Frith, 2006; Ochsner & Gross, 2005). The OFC is responsible for subjective value representation (and, to some extent, valence processing) and emotion evaluation and regulation (Davidson et
General introduction

al., 2000; Rudebeck et al., 2013). The striatum receives dopaminergic input (Gerfen & Surmeier, 2011). In addition to being a key region for the reward system, recent studies of the striatum have revealed a close interplay between the reward system and the affective system (Rutledge et al., 2014). To summarize, neuroimaging findings point toward impairments in initial emotion perception, further affective processing and emotion-related downstream processing in alexithymia.

In addition to neuroimaging studies, a rich literature of EEG studies have shown abnormal emotion processing in alexithymia with regard to the temporal aspects (for reviews, see Goerlich, 2018; Luminet et al., 2021). More specifically, it has been shown that alexithymia is associated with ERPs at different stages of emotion processing. First, early components (approximately before 200 ms after stimulus onset), including P1, N1, N190 and emotional mismatch negativity (eMMN), have been observed to be deviant in the processing of emotional stimuli in alexithymia (Borhani et al., 2016; Goerlich et al., 2012; Pollatos & Gramann, 2011). For example, decreased P1 in response to emotional stimuli has been reported for people with alexithymia (Pollatos & Gramann, 2011), suggesting lower recruitment of attentional resources to process emotion at early, automatic processing stages.

Next, middle-stage components (generally between 200-350 ms), i.e., P2 and N2, have also been shown aberrant in the face of negative stimuli (Campanella et al., 2012; Franz et al., 2004; Walker et al., 2011). Both abnormal amplitudes and latencies for N2 have been observed in individuals with alexithymia, which may reflect difficulties in categorizing emotions (Vermeulen et al., 2008). Finally, abnormal late components (> 350 ms), consisting of P3, N400, slow wave and LPP, have been related to alexithymia in a number of emotion processing paradigms (Goerlich et al., 2011; Pollatos & Gramann, 2011; Walker et al., 2011). For example, reductions in amplitudes of P3, slow wave and LPP have been shown in healthy
controls during successful cognitive reappraisal for negative emotions, while such reductions were absent in the alexithymic group, which may underlie deficient emotion regulation in alexithymia (Pollatos & Gramann, 2011). Importantly, the P1 has been shown to predict the P3 during emotion processing, suggesting that deficits in early components in alexithymia contribute to impaired late emotional processing, thus providing a link between different stages of emotion processing (Pollatos & Gramann, 2011). Furthermore, oscillatory activities derived from time-frequency analysis may be altered during emotion processing in alexithymia. These alterations mainly converge to theta and alpha bands, though some studies also revealed abnormality of the gamma band (for a review, see Goerlich, 2018a). Decreased theta oscillations in alexithymia may suggest impaired valence encoding (L. I. Aftanas et al., 2003), as studies in healthy participants have implied theta oscillations during valence coding (Gable et al., 2021; Kamarajan et al., 2008). Further, atypical alpha oscillations have been reported in people with alexithymia while they were watching emotional film clips, which might indicate abnormal attentional modulation of emotion (L. Aftanas & Varlamov, 2004). Finally, frontal alpha asymmetry (FAA) has been found to be abnormal in people with alexithymia, which may reflect impairments of approach/withdrawal processing (Flasbeck et al., 2017). Taken together, the use of EEG potentially provides important insights into dynamic processes underlying emotion processing alterations in alexithymia.

**Social emotion**

Already back in 1884, William James recognized social features of human emotional life in his seminal work “What is an emotion”. In line with the important role of sociality (i.e., consideration of other people’s thoughts, feelings and actions) in emotional functioning, recent studies have provided biologically plausible evidence for the dimension of sociality in emotion processing (Britton, Phan, et al., 2006; Britton, Taylor, et al., 2006). These studies
reported on the psychophysiological and neural responses to social and nonsocial emotion processing, where sociality was manipulated by whether emotional pictures depicted people or not. Specifically, scenes depicting people are classified as social stimuli (e.g., facial expressions, pictures depicting people in various situations), whereas scenes without people are regarded as nonsocial stimuli (e.g., animals, landscapes, food). From an adaptive standpoint, emotion in the nonsocial domain, or nonsocial emotion, influences basic biological drives, e.g., fighting or fleeing. Emotion in the social domain, or social emotion, on the other hand, affects subjective well-being, quality of life and long-term goal-directed needs, such as obtaining a degree (Britton, Phan, et al., 2006). Focusing on the social dimension, it has been shown that the sociality of emotional-laden stimuli impacts emotion regulation and memory systems, both of which are crucial to individual well-being and higher-order needs (Sakaki et al., 2012; Vrtička et al., 2011). Indeed, a study revealed that induced social negative emotion was associated with feelings of social isolation, which further resulted in negative consequences on social life (Powers et al., 2013). Furthermore, deficits in social emotion processing have been shown in various clinical populations, such as patients with schizophrenia (Peterman et al., 2015) and ASD (Bird et al., 2010). Therefore, investigations of social emotion have considerable implications. Please note that social emotion in this thesis refers to the social dimension of perceived emotional stimuli.

As frequently perceived socio-emotional stimuli, facial expressions are widely used to examine emotion processing in the fields of psychology and affective neuroscience (Calvo & Nummenmaa, 2016; Xu et al., 2021). The classic emotional induction method repeatedly presents different facial expressions in a brief period of time to participants. A fundamental question concerns how people perceive such emotional expressions. It has been shown that people often automatically mimic the observed facial expressions by sensorimotor simulation.
(for a review, see Wood et al., 2016). This ability to understand socio-affective cues from facial expressions, serving as the interface of socio-emotional information, contributes to the perceptive and affective processing of socio-affective facial cues (Wood et al., 2016). Amounting evidence from behavioral and neuroimaging studies (e.g., reading the mind in the eye task) highlights that the eye-region plays the most important role in human face perception (Itier et al., 2011; Kobayashi & Kohshima, 1997). Indeed, a key role of the eye-region in deciphering emotions has been established (Adolphs et al., 2005). In addition to social-emotional processing itself, social emotion profoundly impacts human adaptive behavior through various cognitive activities, such as memory, learning, and information integration (for reviews, see Gilam & Hendler, 2016; Olsson & Ochsner, 2008). For example, alterations in attention deployment and working memory performance were found when processing faces expressing fear (Curby et al., 2019; Shechner et al., 2012). Such findings highlight the relevance of social-emotional processing.

**Social emotion processing in alexithymia**

In addition to a vast amount of behavioral and neuroimaging findings indicating differences in emotion processing between people with and without alexithymia (for reviews, see Donges & Suslow, 2017; Luminet et al., 2021), individuals with alexithymia show abnormal social functioning, such as less altruistic behaviors (FeldmanHall et al., 2013) and poor interpersonal relationships (Grynberg et al., 2010). Impairments of social-specific abilities, including action imitation (Sowden et al., 2016), empathy (Geoffrey Bird et al., 2010; Moriguchi et al., 2007) and theory of mind (Moriguchi et al., 2006), may account for social dysfunction in people with alexithymia. Notably, social-specific impairments of empathic reactions in alexithymia point to the relevance of the socio-emotional dimension (Geoffrey Bird et al., 2010; Moriguchi et al., 2007). Also, the previous meta-analysis of the structural neuroanatomical
changes in alexithymia has suggested deficits in ‘socio-emotional brain’ structures such as the insula and amygdala (Xu et al., 2018). Recently, a new framework of the Self to Other model of empathy has been proposed to understand abnormal social behaviors in alexithymia, contending that an impairment of the affective representation system (i.e., accompanied by the insula and dACC) results in abnormal social behaviors (Geoffrey Bird & Viding, 2014). For example, alexithymia has been observed to be associated with reduced responses of the dACC to social rejection in the Cyberball game, indicating that individuals with high alexithymia levels may fail to benefit from emotional signals to adapt their behaviors in social contexts (Chester et al., 2015). Moreover, deficits in social emotion processing have been shown in patients with ASD and with schizophrenia (Geoffrey Bird & Viding, 2014; Peterman et al., 2015), which are associated with alexithymia. Therefore, substantial evidence has pointed toward impairments of social emotion processing in alexithymia.

Neuroimaging studies on alexithymia using facial expressions as socio-emotional stimuli have revealed neural correlates of social emotion processing in alexithymia (van der Velde et al., 2013). Based on neuroimaging evidence, it has been proposed that executive attention and core affect are of importance for social emotion processing in alexithymia (Lindquist et al., 2012). These mental operations are in line with the attention-appraisal model of alexithymia (Preece et al., 2017), proposing difficulty to focus attention on emotional information in the first stage and difficulty to understand the content and significance of emotional stimuli (appraisal) in the second stage. As suggested by the psychological constructionists, however, there may be an interplay or overlap between executive attention and core affect (Lindquist et al., 2012). In addition, evidence from EEG studies suggests a stage of emotion perception before core affective processing (Calvo & Nummenmaa, 2016). In this thesis, based on previous findings of neural dynamics underlying emotion processing in alexithymia, we
hypothesized involvements of abnormal perception, core affect, and executive attention for social emotion processing in alexithymia, unfolding at the initial perceptive processing stage, the further affective processing stage and a subsequent emotion-related downstream processing stage.

To test these hypotheses, we recorded EEG to examine abnormalities of social emotion processing in alexithymia during a set of emotion-related tasks. Regarding initial perceptive processing and further affective processing, we first attempt to replicate previous findings of impaired socio-emotional processing in alexithymia specifically within a context of high ecological validity—coexistence of audiovisual socio-emotional information (i.e., emotional Stroop-like audiovisual task), given that emotions are inherently multimodal in daily life. Second, a fundamental question in social affective neuroscience concerns social specificity (Lockwood et al., 2020). Although empathetic processing is compromised in alexithymia (Geoffrey Bird et al., 2010; Moriguchi et al., 2007), whether basic emotion processing impairments in alexithymia are social-specific remains unclear, given that empathy is a complex ability involving a set of brain systems (Geoffrey Bird & Viding, 2014). Third, as the most important feature for emotion identification from faces (Adolphs et al., 2005), the role of emotive eye-region processing in alexithymia and the underlying dynamics are unknown. Investigation of dynamics of eye-region processing may provide insights into initial mechanisms of social emotion perception in alexithymia. With regard to emotion-related downstream processing, a large body of evidence has shown cognitive and emotional deficits in alexithymia (Luminet et al., 2021b, 2021a). Since a fundamental aspect of human social life is the seamless ability for integration of emotion and cognition (Gu et al., 2013), recent reviews have suggested impaired emotion-cognitive integration in alexithymia (Luminet et al., 2021b, 2021a). However, empirical evidence is still lacking regarding emotion-cognition
integration in alexithymia, as well as the role of social cues in emotion-cognition integration. Answering these questions may gain significant insights into the downstream processing of social emotion in alexithymia.

**Aims of this thesis**

This thesis aims to examine aberrant neural dynamics underlying social emotion processing in alexithymia, by using EEG. In Chapter 2, we test the psychometric properties of the Chinese version of the BVAQ (n = 439). This study is of importance for assessing the affective dimension of alexithymia in addition to its cognitive dimension, which is essential to cover the entire construct of alexithymia. Chapter 3 aims to examine abnormalities of emotional multisensory integration in relation to alexithymia by recording EEG signals during an emotional Stroop-like audiovisual task (n1 = 25; n2 = 23). To examine social-specific deficits of emotion processing in alexithymia and the underlying electrophysiological substrates, Chapter 4 records electrophysiological responses of individuals with alexithymia (n = 24) and individuals without alexithymia (n = 23) while they view affective scenes that varied on the dimensions of sociality and emotional valence during a rapid serial visual presentation task. To further test the cognitive and electrophysiological mechanisms underlying emotive eye-region processing in alexithymia, Chapter 5 reports recordings of behavioral and electrophysiological responses of individuals with alexithymia (n=25) and individuals without alexithymia (n=23) while they view intact and eyeless faces with angry and sad expressions during a rapid serial visual presentation task. Next, we investigate the downstream processing of social emotion, e.g., the interaction between emotion and cognition, in alexithymia in social and nonsocial contexts, respectively. Specifically, Chapter 6 examines the temporal organization of brain oscillations underpinning emotion-cognition integration in alexithymia. We simultaneously manipulate the emotional valence of stimuli (pain versus no pain) and
cognitive task demand (low versus high) while recording electrophysiological responses of 61 participants. Stimuli used in this study merely display isolated parts of the human body to get rid of social-emotional features. Expanding the research on emotion-cognition integration into the social domain, Chapter 7 examines the neuro-computational mechanisms underlying the influences of fear on adaptation to volatility and its association with alexithymia (n = 61). Specifically, we use a novel cue-biased adaptation learning task, during which we simultaneously manipulated the emotional valence of cue (fearful versus neutral expressions) and environmental volatility (frequent versus infrequent reversals). Notably, fear is elicited by fearful facial expressions, which could be classified as social stimuli.

Finally, Chapter 8 summarizes findings of all these studies. Together with previous models and findings on emotion processing in alexithymia, I propose a model that delineates social-specific neural dynamics of emotion processing in alexithymia. This model provides new insights into impairments of emotion processing for people with alexithymia in daily life and has theoretical and practical implications regarding the management and treatment of alexithymia-related mental disorders.
References


https://doi.org/10.1016/j.neuroimage.2005.11.027


Li, S., Zhang, B., Guo, Y., & Zhang, J. (2015). The association between alexithymia as assessed by the 20-


https://doi.org/10.1093/scan/nst188


https://doi.org/10.1016/j.comppsych.2007.04.007

https://doi.org/10.1037/tra0000433