

Neural Mechanisms of Dynamic Emotional Face Recognition in Individuals with High Social Anxiety

Authors: Ran Guangming, Li Rui, Zhang Qi, Ran Guangming

Date: 2020-09-11T00:00:00+00:00

Abstract

In recent years, a substantial body of research has examined emotional face processing in individuals with high social anxiety and interventions for social anxiety, yielding fruitful results. However, several limitations remain: (1) previous Chinese dynamic emotional face databases have featured limited varieties of emotional categories, video dimensions, and video durations for stimulus materials; (2) the neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals have not been systematically investigated; and (3) the effectiveness of attention bias training remains controversial, with some researchers finding significant alleviating effects of such training on social anxiety while others have observed no such effects. To address these limitations, the Chinese Dynamic Emotional Face Database currently under development by this project aims to increase the types of emotional categories, video dimensions, and video durations of stimulus materials. Additionally, neuroscientific techniques will be employed to systematically investigate the recognition mechanisms of dynamic emotional faces in high social anxiety individuals. Finally, working memory training will be adopted to improve attentional bias toward dynamic angry faces in high social anxiety individuals. Our research team has proposed a neural mechanism model for dynamic emotional face recognition in high social anxiety individuals, which mainly comprises two components: mechanisms and interventions. The implementation of this project not only provides a new perspective for research on dynamic emotional face processing and social anxiety but also breaks through the original single research methodology by conducting studies at three levels: behavioral, electrophysiological, and brain imaging. The research findings will facilitate the development of social anxiety interventions, thereby alleviating mental health issues in individuals with social anxiety and holding significant value for improving their well-being and quality of life.

Full Text

Preamble

Neural Mechanisms Underlying the Recognition of Dynamic Emotional Faces in High Social Anxiety Individuals

Ran Guangming¹, Li Rui¹, Zhang Qi²

¹Department of Psychology, School of Education, China West Normal University, Nanchong 637002

²College of Preschool and Primary Education, China West Normal University, Nanchong 637002

Abstract

In recent years, numerous studies have examined emotional face processing and social anxiety interventions in high social anxiety individuals, yielding rich findings. However, several limitations remain: (1) Previous Chinese dynamic emotional face databases have limited varieties of emotional categories, video dimensions, and video durations; (2) The neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals have not been systematically investigated; (3) The efficacy of attention bias training remains controversial, with some researchers finding significant anxiety-reducing effects while others find no such effects. To address these limitations, the current project will develop a Chinese dynamic emotional face database with expanded emotional categories, video dimensions, and duration types, systematically investigate the recognition mechanisms of dynamic emotional faces in high social anxiety individuals using neuroscientific techniques, and finally employ working memory training to improve attentional biases toward dynamic angry faces in this population. Our research team proposes a neural mechanism model for dynamic emotional face recognition in high social anxiety individuals, comprising both mechanism and intervention components. This project not only provides a new perspective for research on dynamic emotional face processing and social anxiety but also breaks away from previous single-method approaches by integrating behavioral, electrophysiological, and brain imaging levels of analysis. The findings will promote social anxiety intervention efforts, thereby alleviating mental health problems in socially anxious individuals and holding significant value for improving their well-being and quality of life.

Keywords: social anxiety; dynamic faces; emotion; attentional bias; working memory training; ERP and fMRI

1. Problem Statement

Social anxiety refers to an anxious state exhibited by individuals during daily social interactions with others (Pierce, 2009; Ran et al., 2018). Social anxiety problems typically begin in childhood or adolescence, and as severity increases,

may develop into social anxiety disorder (Iverach & Rapee, 2014). Although social anxiety represents a preliminary form of social anxiety disorder, it frequently interferes with interpersonal functioning and generates numerous negative experiences during social interactions (Mathew et al., 2011). High social anxiety participants (non-clinical or subclinical socially anxious individuals) typically exhibit hypervigilance toward threatening stimuli such as angry faces (Kirsch, 2015; Zhang et al., 2018). In recent years, scholars have intensively investigated the neural mechanisms of emotional face processing in high social anxiety individuals. However, faces perceived in daily life are dynamic rather than static. Therefore, the current project aims to systematically investigate the neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals using event-related potentials (ERPs) and functional magnetic resonance imaging (fMRI) technologies.

The current project holds significance in three main respects. First, it will contribute to developing a more comprehensive Chinese dynamic emotional face database, with materials freely available to researchers for scientific investigation, thereby enhancing the ecological validity of Chinese emotional face research and advancing cross-cultural studies of dynamic emotional faces. Second, it will provide both temporal and spatial information about brain activity during dynamic emotional face processing in high social anxiety individuals, clarify the advantage effect and configural processing of dynamic emotional face recognition in this population, and resolve inconsistencies in conflict experiments examining attentional biases toward threatening faces, ultimately enriching theoretical and empirical research on dynamic emotional face processing and social anxiety. Finally, the project will promote the development of social anxiety interventions, helping to fundamentally alleviate mental health problems in socially anxious individuals and holding practical significance for improving their happiness and quality of life.

2. Research Status

Faces represent the most common visual stimuli in social interaction, containing abundant social information including others' emotions, race, attractiveness, trustworthiness, gender, and age (Ran, Chen, Pan, Hu, et al., 2014; Zhang et al., 2015). Given the current project's focus on dynamic emotional face processing, we first review the status of dynamic emotional face database construction, then summarize emotional face processing in high social anxiety individuals, and finally examine intervention research on social anxiety (attention bias training).

2.1 Status of Dynamic Emotional Face Database Construction

Foreign researchers have developed several dynamic emotional face systems. Kanade et al. (2000) established the CK dynamic facial expression database, the most frequently used dynamic emotional face database internationally. The CK database primarily features American performers aged 18-50. In contrast, the Amsterdam dynamic facial expression set developed by Van der Schalk

et al. (2011) includes European performers aged 18-25. Interestingly, some databases incorporate auditory materials, such as the Italian audiovisual emotion database and the Humaine database (Douglas-Cowie et al., 2007). Beyond 2D dynamic face databases, Yin et al. (2008) developed the Birmingham University 3D dynamic facial expression database.

Notably, emotional stimuli exhibit significant cultural differences. Previous research has found that humans demonstrate other-race effects in emotional face recognition, whereby recognizing faces of other races proves more difficult than recognizing faces of one's own race (Malpass & Kravitz, 1969). Chinese and Western cultures differ markedly, making foreign stimulus materials unsuitable for direct application in domestic research and necessitating the development of indigenous emotional stimulus materials (Huang & Luo, 2004). Consequently, Chinese researchers have established standardized Chinese static emotional picture systems, such as the Chinese Facial Affective Picture System (CFAPS) (Wang & Luo, 2005; Gong et al., 2011) and the Chinese Affective Picture System (CAPS) (Bai et al., 2005). Additionally, some domestic researchers have preliminarily developed the Chinese Facial Expression Video System (CFEVS) (Du et al., 2007). The CFEVS includes three types of dynamic emotional faces (happy: 61 clips; sad: 51 clips; neutral: 31 clips), with each video lasting 3 seconds. Du et al. (2007) evaluated the valence and arousal of these face stimuli, finding that ratings for the three types of dynamic emotional faces were consistent with the characteristics of the expressions themselves.

2.2 Emotional Face Processing in High Social Anxiety Individuals

In recent years, research on emotional face processing in high social anxiety individuals has proliferated, yielding substantial findings. We first review studies on dynamic emotional face processing, then examine the neural mechanisms of static emotional face processing.

2.2.1 Dynamic Emotional Face Processing in High Social Anxiety Individuals

Some researchers have noted that studies using static emotional faces have not found consistent interpretation biases in social anxiety (interpretation bias represents a crucial cognitive bias manifestation in socially anxious individuals, referring to the tendency to misinterpret social stimuli in more negative or threatening ways) (Heuer et al., 2010; Li & Feng, 2013). Heuer et al. (2010) argue that such inconsistent results arise because static emotional face materials are not optimal for investigating psychological processing in everyday life. Specifically, the social environment is complex, information-rich, and uncertain, whereas static emotional faces convey definite emotional information. Alves' (2013) meta-analysis found that different brain regions are activated when individuals recognize dynamic versus static emotional face stimuli, indicating that these represent distinct psychological processes. Furthermore, Ruffman et al.'s (2008) meta-analytic review found that older adults' emotion recognition is influenced by stimulus type. Similarly, a recent meta-analysis showed that

task type (picture/video tasks) affects older adults' emotional face recognition (Hayes et al., 2020). These meta-analytic findings suggest that dynamic and static emotional face stimuli exert different influences on emotional processing, necessitating investigation of dynamic emotional face processing in high social anxiety individuals.

Current research on dynamic emotional faces in high social anxiety individuals has primarily focused on behavioral experiments. Early behavioral studies typically employed morphed faces tasks to examine dynamic face recognition abilities (Joormann & Gotlib, 2006). Subsequent studies using variants of this task investigated dynamic emotional face processing in high social anxiety individuals, finding that under time constraints, high social anxiety participants perceived dynamic disgust faces as more threatening, though this effect was not observed under unlimited time conditions (Heuer et al., 2010). Gutiérrez-García and Calvo (2017) further examined dynamic emotional face processing in high social anxiety individuals, revealing that social anxiety-related interpretation bias represents an expression encoding bias rather than a response bias.

2.2.2 Neural Mechanisms of Static Emotional Face Processing in High Social Anxiety Individuals

Numerous ERP studies have investigated static emotional face processing in high social anxiety individuals. The first relevant ERP component is P100, a key electrophysiological index of early visual processing (Taylor & Khan, 2000). Research has found that high social anxiety individuals exhibit significantly larger P100 amplitudes when processing threatening static faces such as angry faces compared to low social anxiety individuals (Mühlberger et al., 2009; Peschard et al., 2013). Interestingly, Rossignol et al. (2012) found that high social anxiety individuals also show larger P100 amplitudes when processing non-threatening static faces such as happy faces. The negative ERP wave following P100 is the N170 component, which primarily relates to featural face processing (Ran & Chen, 2017). Some researchers have found that high social anxiety individuals exhibit larger N170 amplitudes when identifying threatening static faces (Wieser et al., 2010; Ran & Chen, 2017), while others have not observed this threat perception bias (Mühlberger et al., 2009; Lin et al., 2017). These inconsistent results may stem from different experimental tasks employed (Zhang et al., 2018). For instance, Mühlberger et al. (2009) used an implicit emotion task, whereas Ran and Chen (2017) employed an explicit emotion task. P300 represents an important positive component appearing in later cognitive processing stages. Research has found that high social anxiety individuals show larger P300 amplitudes when perceiving neutral pictures in negative self-relevant contexts (Wieser & Moscovitch, 2015). Beyond traditional ERP analyses, scholars have adopted novel analytical techniques. Jin et al. (2019) used time-frequency analysis, finding that high social anxiety individuals exhibited higher delta band power during social feedback conditions (evoked by static emotional faces), indicating greater sensitivity under these experimental conditions. Additionally, Xing et al. (2017) employed EEG functional connectivity analysis, finding that compared to control groups,

high social anxiety individuals showed stronger oscillatory midline coherence in the theta band, suggesting higher connectivity in the functional networks constructed from their EEG data.

In addition to ERP technology with high temporal resolution, fMRI technology with high spatial resolution has been widely used to investigate the neural basis of human emotional face processing. Early research found that participants' social anxiety scores positively correlated with activation levels in the amygdala (Pujol et al., 2009). Subsequent studies observed significant differences in brain activation between high social anxiety individuals and social anxiety disorder patients when perceiving static emotional faces (Abraham et al., 2013). A recent fMRI study using functional connectivity analysis found that high social anxiety individuals showed weakened connectivity between the prefrontal cortex and threat-processing sensory cortical areas during emotion regulation (Kreifelts et al., 2017).

In summary, ERP components related to static emotional face processing in high social anxiety individuals include P100, N170, and P300, while relevant brain regions involve both cortical areas (e.g., prefrontal cortex) and subcortical areas (e.g., amygdala). Notably, existing findings on the neural mechanisms of emotional face processing in high social anxiety individuals have not addressed dynamic emotional faces. Future neuroscientific research should examine more ecologically valid dynamic stimuli to more comprehensively investigate emotional face processing mechanisms in high social anxiety individuals.

2.3 Attention Bias Training for Social Anxiety

Attentional bias refers to differential attention allocation toward threatening or relevant stimuli compared to neutral stimuli (Wang et al., 2011). Attention bias training (ABT), also known as attention bias modification (ABM), represents a training method that modifies or corrects individuals' attentional biases through specific tasks (Amir et al., 2009; Beard et al., 2012; Wang et al., 2011; Zhao et al., 2014). ABT paradigms primarily involve the dot probe task (DPT) and visual search task (VST). The ABT dot probe task differs from the standard version in the probability of probe appearance following target and neutral stimuli (Kuang, 2018; Jiang et al., 2019). Specifically, when the training aims to increase attentional bias toward target stimuli, probes appear predominantly or exclusively at the location where target pictures disappeared. Conversely, when aiming to reduce attentional bias toward certain stimuli, probes appear following irrelevant pictures. The visual search task in ABT research aims to train individuals' visual attention patterns. For example, in Kruijt et al.'s (2013) study, training group participants performed a "find the happy face" task (rapidly locating a happy face among 15 disgust faces and 1 happy face), while control group participants performed a "find the flower" task (rapidly locating a five-petal flower among 15 seven-petal flowers).

Research indicates that high social anxiety individuals allocate more attentional

resources to threatening stimuli in the environment compared to neutral stimuli (Gan & Li, 2010). Huang et al. (2017) note that selective attention to threatening stimuli enhances processing of negative social information in high social anxiety individuals, thereby initiating, maintaining, or even intensifying their anxiety in social situations. Consequently, timely correction of threat-related attentional biases in high social anxiety individuals proves particularly necessary. Interestingly, ABT techniques enable researchers to manipulate attentional biases toward threat information, thereby reducing anxiety symptoms (Bar-Haim et al., 2007). Some studies have demonstrated that ABT significantly alleviates social anxiety (Amir et al., 2008; Eldar et al., 2012; Heeren et al., 2012; De Voogd et al., 2014). However, other researchers have failed to find significant effects of ABT on social anxiety symptoms (Boettcher & Renneberg, 2012; Heeren et al., 2015). These conflicting findings indicate that the efficacy of ABT for high social anxiety individuals requires further investigation.

2.4 Limitations of Existing Research

Previous scholars have conducted impressive work on social anxiety and dynamic emotional face research, including dynamic emotional face database construction, investigation of emotional face processing in high social anxiety individuals, and attention bias training for social anxiety. Despite initial attempts to explore the relationship between social anxiety and dynamic emotional faces, several pressing issues remain unresolved.

First, existing Chinese dynamic emotional face databases remain inadequate. Although CFEVS research has yielded admirable results, three aspects warrant further investigation: (1) CFEVS includes only one type of negative (sad) dynamic emotional face, constraining relevant research. Literature reviews reveal that emotional face studies also employ angry, fearful, and disgusted faces (Peschard et al., 2013; Ran & Chen, 2017). Research has found that high trait anxiety individuals show significant differences in perceiving sad versus angry faces, with shorter reaction times for arrays containing angry faces compared to sad faces (He, 2010). (2) Regarding video dimensions, CFEVS only assessed valence and arousal, without evaluating dominance, attractiveness, or trustworthiness. Studies have shown that these dimensions affect face processing (Li et al., 2018; Zhang et al., 2016). Incomplete video dimensions limit CFEVS applicability. (3) CFEVS videos last 3 seconds, which, while suitable for fMRI research, are inappropriate for ERP studies with high temporal resolution, where target stimuli should not exceed 1 second.

Second, the neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals have not been systematically investigated. As previously noted, research on dynamic emotional face processing in this population has primarily employed behavioral methods. Although Zhang et al.'s (2018) ERP study preliminarily examined perception of emotional changes in others, the face stimuli were simulated using morphing software, resulting in low ecological validity that differs significantly from real-world emotional faces. Numerous

meta-analyses and empirical studies demonstrate that dynamic emotional faces possess higher ecological validity and are more suitable for emotion research (Alves, 2013; Arsalidou et al., 2011; Forni-Santos & Osório, 2015; Pelphrey et al., 2007; Trautmann et al., 2009). First, dynamic emotional faces present more realistic emotional changes (Arsalidou et al., 2011). Second, they elicit higher levels of psychological activation (Alves, 2013). Finally, dynamic information processing proves crucial in social interaction (Pelphrey et al., 2007). Therefore, ERP technology should be used to investigate processing of ecologically valid dynamic emotional faces (filmed faces) in high social anxiety individuals to reveal the essence of their emotional processing. Investigation of these neural mechanisms should not be limited to electrophysiological mechanisms but should also employ fMRI to examine brain activation patterns, a neglected area in previous research. This combined electrophysiological-neuroimaging approach offers good continuity and comprehensiveness for investigating the neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals. Three aspects deserve particular attention: (1) Further clarifying attentional biases toward threatening faces in high social anxiety individuals. Cognitive models of social anxiety indicate that threat-related attentional biases contribute to the persistence and development of social anxiety (Liu & Yang, 2013). Numerous cognitive neuroscience experiments have investigated these biases, but results remain inconsistent. Liu and Hu's (2013) comprehensive review of neuro-level studies supporting and refuting attentional biases toward static threatening faces in high social anxiety individuals identified multiple sources of divergence, including experimental materials, tasks, and participants. (2) Determining whether high social anxiety individuals exhibit an advantage effect for dynamic emotional face recognition. Zhang et al. (2015) note that the neural network for this advantage effect involves temporal-occipital core regions and extended areas (e.g., amygdala, anterior cingulate cortex, inferior frontal gyrus, and inferior parietal lobule). Evidence suggests that high social anxiety individuals show abnormal activation in these regions compared to controls (Amir et al., 2005; Freitas-Ferrari et al., 2010), indicating they may not exhibit the dynamic emotional face recognition advantage effect. (3) Examining configural face processing in high social anxiety individuals. Recent ERP research indicates impaired configural processing during static emotional face recognition in this population (Ran & Chen, 2017). Zhang et al. (2015) suggest that facial motion can enhance configural processing, implying that impaired configural processing may improve when high social anxiety individuals perceive dynamic emotional faces. Investigating these issues will not only deepen understanding of dynamic emotional face recognition advantage effects and configural processing but also help clarify reasons for inconsistent findings regarding attentional biases toward threatening faces.

Finally, the efficacy of attention bias training remains controversial. As described above, some researchers have found significant anxiety-reducing effects (Amir et al., 2008; Eldar et al., 2012; Heeren et al., 2012; De Voogd et al., 2014), while others have not (Boettcher & Renneberg, 2012; Heeren et al., 2015). Two

main factors contribute to these conflicting results. First, the credibility of previously selected ABT paradigms warrants consideration. Zhao et al. (2020) recently noted that using the dot probe task to modify attentional biases in high social anxiety individuals may not be optimal. Attention control theory posits that negative cognitions in high social anxiety individuals reduce attentional resources for current tasks, impairing central executive system attentional control functions and ultimately increasing attentional biases toward threatening stimuli (Eysenck & Derakshan, 2011; Zhao et al., 2020). Notably, the dot probe task cannot effectively remediate these central executive system deficits (Zhao et al., 2020). The central executive system, considered the core component of working memory, primarily controls processing within working memory (Zhao & Zhou, 2011). Working memory training has emerged as an effective method for improving cognitive performance (Liu & Zhou, 2011). Recent studies have found that working memory training can effectively improve attentional control deficits in high social anxiety individuals, thereby reducing anxiety levels (Du Toit et al., 2020; Sari et al., 2016; Zhao et al., 2020; Zhao & Dang, 2019). Therefore, working memory training should be employed when correcting attentional biases toward dynamic angry faces in high social anxiety individuals. Second, another reason for controversial ABT effects is the excessive reliance on single assessment measures in previous studies (Zhao et al., 2014). Future research should comprehensively employ behavioral, electrophysiological, and brain imaging measures to evaluate training effects.

3. Research Plan

Based on the above, this study will integrate behavioral, ERP, and fMRI methods to systematically investigate the neural mechanisms underlying dynamic emotional face recognition in high social anxiety individuals across three aspects: constructing a comprehensive Chinese dynamic emotional face database, examining the neural mechanisms of dynamic emotional face recognition, and investigating working memory training for attentional biases toward dynamic angry faces.

3.1 Study 1: Construction of a Chinese Dynamic Emotional Face Database

Given the urgency of developing a comprehensive Chinese dynamic emotional face database, Study 1 will conduct three experiments. Experiment 1 will film Chinese dynamic emotional faces, including six basic emotions (anger, disgust, fear, happiness, sadness, surprise) and one neutral expression (Ekman et al., 1972; Ekman & Friesen, 1978). Raw video materials will be processed in two ways: (1) removing external features such as ears, hair, and neck, retaining only internal features including eyes, nose, mouth, and cheeks (Peng et al., 2003; Wang & Luo, 2005); (2) proportionally scaling original videos while retaining all features, presented within uniformly sized blue background frames. Experiment 2 will evaluate the Chinese dynamic emotional face materials using rating

manuals that reference self-assessment models to evaluate valence, arousal, dominance, attractiveness, and trustworthiness (Britton et al., 2006). Experiment 3 will investigate differences in recognizing Chinese versus Caucasian dynamic emotional faces, manipulating two variables: dynamic emotional face type (negative, positive, neutral) and face race (Chinese, Caucasian). The classic S1-S2 paradigm will be used (Zhang et al., 2018), which has proven effective for examining own-race and other-race face recognition (Ran, Chen, & Pan, 2014; Ye et al., 2009).

3.2 Study 2: Neural Mechanisms of Dynamic Emotional Face Recognition in High Social Anxiety Individuals

Previous research on dynamic emotional face processing in high social anxiety individuals has primarily employed behavioral methods. To investigate the neural mechanisms, Study 2 will use high-temporal-resolution ERP technology (Experiment 4) and high-spatial-resolution fMRI technology (Experiment 5). Key research content involves three aspects: (1) attentional biases toward dynamic negative faces in high social anxiety individuals; (2) whether high social anxiety individuals exhibit a dynamic emotional face recognition advantage effect; and (3) configural face processing in high social anxiety individuals. Both experiments will manipulate three variables: emotion type (negative, positive, neutral), face type (dynamic, static), and social anxiety group (high, low). The S1-S2 paradigm and dot probe paradigm will be used. Prior to experiments, participants will be assessed using the Chinese version of the Liebowitz Social Anxiety Scale (He & Zhang, 2004). In previous research (Ran & Chen, 2017; Zhang et al., 2018), individuals scoring above 60 were classified as high social anxiety, while those scoring below 40 were classified as low social anxiety. Based on these criteria, high and low social anxiety groups will be selected, showing significant differences in social anxiety scores but not in other factors such as trait anxiety, state anxiety, or depression. Given the limitations of ERP methods, non-traditional analyses including time-frequency analysis, functional connectivity, and microstate analysis will be employed alongside conventional amplitude and latency analyses.

3.3 Study 3: Working Memory Training for Attentional Bias Toward Dynamic Angry Faces in High Social Anxiety Individuals

Review of previous research indicates controversial effects of attention bias training. To address this issue, the current project will use ERP (Experiment 6) and fMRI (Experiment 7) to investigate working memory training for attentional bias toward dynamic angry faces in high social anxiety individuals. Results from both experiments will provide electrophysiological and brain activation pattern evidence for training efficacy, enhancing objective evaluation of social anxiety intervention effects. Both experiments will manipulate variables of time (pre-test, post-test) and group (training, control). Half of the high social anxiety participants will be assigned to the working memory training group and half to

the control group. Due to significant variations in experimental tasks, outcome measures, and participant characteristics across working memory training studies, obtaining an expected effect size proves challenging (Zhao et al., 2020). To address this, the current study will use effect sizes from similar previous research as benchmarks, adopt an acceptable statistical power ($1-\beta > 0.80$), and calculate required sample sizes using G*Power (Faul et al., 2007). Due to different equipment requirements for stimulus presentation, Experiments 6 and 7 will use dynamic emotional faces with durations of 1000 ms and 3000 ms, respectively. The primary objective is to determine whether improvement in attentional bias mediates the relationship between working memory training effects and anxiety reduction. Specifically, working memory training is expected to improve attentional control deficits, thereby reducing or eliminating attentional biases toward dynamic angry faces and ultimately decreasing anxiety levels in high social anxiety individuals.

4. Expected Results and Theoretical Construction

This project breaks away from previous single-method approaches by integrating behavioral, electrophysiological, and brain imaging levels, providing multi-angle, multi-dimensional, and multi-level evidence. The project predicts several outcomes. First, due to the feasibility of the database construction design, Experiments 1 and 2 are expected to produce a comprehensive Chinese dynamic emotional face database. Second, based on other-race effects (Zhou et al., 2009), Experiment 3 is expected to show that Chinese participants exhibit processing disadvantages when recognizing Caucasian dynamic emotional faces. Third, as facial motion can enhance configural processing, neurocognitive results from Experiments 4 and 5 will demonstrate improved configural processing when high social anxiety individuals perceive dynamic emotional faces. Additionally, based on hypervigilance toward threatening stimuli and abnormal brain activation in high social anxiety individuals (Amir et al., 2005; Bantini et al., 2016; Freitas-Ferrari et al., 2010; Lee & Telch, 2008), we hypothesize that high social anxiety individuals will show attentional biases toward dynamic angry faces and will not exhibit the dynamic emotional face recognition advantage effect shown by low social anxiety individuals. Fourth, inconsistent intervention effects in previous research may stem from ineffective training paradigms and single assessment measures. To address these limitations, Experiments 6 and 7 will employ working memory training and integrate behavioral, electrophysiological, and brain imaging measures. Therefore, we hypothesize that working memory training can reduce attentional biases toward dynamic angry faces and decrease anxiety responses in social situations among high social anxiety individuals.

[Figure 1: see original paper]

Based on these expected results, we propose a neural mechanism model for dynamic emotional face recognition in high social anxiety individuals (Figure 1). The model comprises mechanism and intervention components. In the mechanism component, cognitive neuroscience (ERP and fMRI) evidence indicates

that high social anxiety individuals exhibit: (1) improved configural face processing; (2) attentional biases toward dynamic angry faces; and (3) absence of dynamic emotional face recognition advantage effects. In the intervention component, ERP and fMRI evidence shows that after working memory training, high social anxiety individuals demonstrate reduced attentional biases toward dynamic angry faces and improved dynamic emotional face recognition advantage effects, which in turn reduce anxiety levels.

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