Comparisons are Odious? The Neural Mechanism of Intergroup and Intragroup Social Comparison among Game Players: An fMRI Study

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Abstract

Social comparison is an important way for individuals to define their social characteristics, and online games with a large number of social information provide a convenient platform for social comparison between players. At the same time, the spontaneous self-classification brought by social information makes the social comparison process among players potentially affected by group identity. This study explored the neural mechanism of intergroup and intragroup social comparison among players through fMRI and point estimation paradigm. 26 subjects participated in our experiment, and 25 of their head movement amplitudes were less than 2.5mm and were included in the statistics. We found that the downward comparison led to significantly different brain activation compared with the upward comparison. The fusiform gyrus, putamen, lentiform nucleus, precuneus and precentral gyrus were significantly activated when the group identity of the comparison object was the same as that of the player. When the two have different identities, downward comparison significantly activated the angular gyrus, middle frontal gyrus and superior frontal gyrus. Our research has proved that group identity has a moderating effect on social comparison cognitive process among players. When the object of downward comparison is an out-of-group member, the player will receive the reward information and positive emotional valence, which can positively predict their continuous game behavior in theory. This study provides a new possibility for the cause of game addiction at the perspective of neural mechanism.

Introduction

When people define their social characteristics (such as ability, intelligence, etc.) in real life, they often obtain their meaning in a comparative social environment by comparing with others around them, rather than according to purely objective standards. Festinger (1954) calls this phenomenon social comparison. It can be further subdivided into upward and downward in direction, and assimilation and contrast in dimension (Buunk, 1997). In our life, whether individuals or groups, it is easy to consciously or unconsciously understand their social status and self-worth by comparing with others.

Social comparison is one of the core processes of social cognition, which plays an important role in making rational decisions, building good interpersonal relationships, correctly understanding oneself and regulating negative emotions (Gilbert et al., 1995; Mussweiler, 2001). On the other hand, however, different comparison directions and objects may also lead to opposite effects such as anxiety (Hai & Yang, 2022), SNS addiction (Kim, Schlicht, Schardt & Florack, 2021), lower well-being (Gerson et al., 2016; Yang et al., 2019) and even suicide intention (Spitzer et al., 2023).
The cause of the above negative effects may be the competition caused by incorrect social comparison. Research findings suggest social comparison may be the root cause of competitiveness (Garcia et al., 2013), while competitiveness has been found as an important factor leading to game players’ aggressiveness (Anderson & Carnagey, 2009) and addiction (Wang & Cheng, 2022) in recent years. An experiment by Esteves (2021) demonstrated that the inclination of social comparison can significantly predict players’ game behavior, and different social comparison directions and dimensions have different effects. Based on this, we believe that it is an interesting topic with certain theoretical value to explore the social comparative cognitive mechanism of game players in the game and how it affects the players’ willingness to continue playing.

**Social Comparison and Problem Gaming Use**

For game players, there is a special and frequent form of social comparison, that is, social comparison from a group perspective. Such as player guilds and teams in the game, which could lead to frequent comparisons and competition. Especially for IGD individuals, the pursuit of achievement and immersion motivation may enable them to find their own group in the game (Yee, 2006), thus generating group identity. Group identity is not some product of its individual building blocks, but the primary foundation for much of our being and behavior. Meanwhile, social isolation and anonymity in the Internet will enhance the impact of group identity, such as stereotype, group polarization, etc (Spears, 2020).

Actually, many researchers suggest that pathological gaming is more prevalent among players of online games than among players of offline games (BRIAN & Wiemer-Hastings, 2005; Ko et al., 2009; Seo et al., 2009; Smyth, 2007). Lemmens found that time spent playing online games had significantly stronger correlation with IGD than offline games (Lemmens & Hendriks, 2016). One of the most evident antecedents of pathological gaming is a lower psychosocial well-being (Lemmens et al., 2011; Gentile et al., 2011). Specifically, players who report more loneliness, lower self-esteem, and lower social competence are more likely to develop signs of game addiction (Pratagalli, Browne & Johnson, 1999). Virtual online worlds can provide players with a community where lonely gamers with low self-esteem and diminished social skills may avoid their real-life deficiencies through virtual social contacts and achievements. The social interaction provided by online multiplayer games is particularly appealing to people who are socially unskilled, have an unmet need for sociability in their offline lives, or feel anxious over establishing real-life interpersonal relationships (Chak & Leung, 2004; Peters, 2008). A sense of group belonging which comes from the satisfaction of needs increases the enjoyment players perceived in the online game, promotes in-game behavior (Hsiao & Chiou, 2012; Kim et al., 2018), and even affects their behavior in real life (Jung, 2020).

The satisfaction of social needs makes players have a sense of group belonging and group identity, which will further affect their social interaction behavior inside and outside the game, such as social comparison. A series of studies have confirmed the influence of group identity on social comparison outcomes. For example, Robert (Lount & Phillips, 2007) found that in the same situation of upward comparison, when the comparison object is an out of group individual, the individual will make more efforts to promote themselves. On the other hand, Benjamin found that intragroup comparisons in anonymity situation boosted individuals’ mental creativity (Benjamin, Nicolas & Olivier, 2018). One plausible explanation for why this occurs is that the presence of social category differences triggers expectations that disagreements will occur thereby heightening the likelihood that people will carefully process the available information (Phillips, 2003, 2006).
In a nutshell, the satisfaction of online games to the social needs of players and the social comparison between players may lead to the willingness and behavior to continue playing, or even develop into problematic use. Meanwhile, the sense of group belonging and group identity which come from the needs satisfaction may expand the influence of social comparison, and become the catalyst of problematic game behavior. We built a framework diagram to illustrate our assumptions.

**Figure 1 Hypothesis Model of Online Games causing Problem Gaming Use**

The lower one is the need satisfaction path, where online games serve as positive reinforcement to meet the player’s social needs, thus reinforcing the willingness and behavior to continue playing. This path is consistent with the experimental results of related studies (Bhagat, Jeong, & Kim, 2019; Gyla et al., 2020). The top one is the social interaction path. In online games, social interaction processes, including social comparison, also indirectly affect play behavior. When social needs are met, players will spontaneously develop a group identity and a sense of belonging. This process will regulate the process of social comparison, making social comparison lead to different effects based on its dimension and direction.

### 1.2. The neural mechanism of social comparison

Although a considerable number of studies have demonstrated the differential impact of social comparison in the context of group classification (Lount & Phillips, 2007; Benjamin et al., 2018; Isobe, Ura, & Hasegawa, 2005), and studies have also found that social comparison has an impact on game behavior (Esteves et al., 2021), there is still a lack of evidence at the neural mechanism level.

According to the direction of social comparison, some researchers explored the activation of brain regions produced by upward comparison and downward comparison respectively. For example, the ventral striatum is significantly activated when the absolute gain is higher than others and the absolute loss is lower than others, that is, when an downward comparison is made (Fliessbach, 2007). Similarly, the ventromedial prefrontal cortex, as one of the important brain regions involved in social cognition, will be activated when the expectation of getting better results than others is met to form a “relative reward” (Shapiro & Grafton, 2020). The activation of these two brain regions indicates the presentation of rewards and positive stimuli (Mcclure, York, & Montague, 2004; Maia et al., 2016).

In contrast, upward comparisons often occur when the results contradict expectations. On the one hand, negative results and negative emotional experiences lead to physical pain and social pain, which trigger the activation of the dorsal anterior cingulate cortex (Civai et al., 2012). Other studies have found that when an individual is at a relative disadvantage compared with others, the dorsolateral prefrontal cortex also has an activation pattern similar to the former (Klaus et al., 2012). On the other hand, in the context of upward social comparison, the anterior insula and amygdala will also be activated at a certain level (White et al., 2014; Zheng et al., 2015; Zink et al., 2008). These two brain regions play an important role in the cognitive processing of emotional pain and are mainly responsible for the representation of negative emotions.
In the context of intergroup comparison, interpersonal social comparison will have certain changes. The identification of the group to which individuals belong may affect their reaction to the comparison object (Blanton et al., 2000, 2002). According to Turner’s self-categorization theory (SCT), people may category themselves and comparison object as members of a certain group (Hogg & Turner, 2011). When people regard they are in a same group, as selective accessibility model (SAM) proposes, it will lead to a similarity testing, which further trigger assimilation effect. On contrast, when people regard they have different group identities, it will lead to a dissimilarity testing, which further trigger contrast effect (Mussweiler, 2003). Figure 2 illustrated the cognitive path of social comparison constructed by combining the two above theories.

**Figure 2 The cognitive path of social comparison constructed by combining SCT and SAM**

Assimilation effect caused by intragroup comparison refers to the phenomenon that when individuals face social comparison information, their self-evaluation level is oriented to the comparison target, while it may lead to an arousal of self reference (Collins & Rebecca, 1996). In an early study, Shinpei found that the medial prefrontal gyrus, posterior cingulate gyrus, and precuneus are associated with a self-referential processing, and the ventral anterior cingulate gyrus is involved in self-referential processing of negative emotional stimuli (Shinpei et al., 2009). A subsequent self-referential study by Yaoi have reached similar conclusions (Yaoi et al., 2015).

Contrast effect caused by intergroup comparison refers to the phenomenon that when individuals face social comparison information, their self-evaluation level deviates from the comparison target, while it may lead to an arousal of competition or motivation (Blanton, 2001). As for the competition, the inferior parietal and medial prefrontal cortices were found associated with this specific mental set (Jean et al., 2004). At the same time, Spielberg’s research pointed out that the activation of bilateral middle frontal gyrus is related to the type of state motivation used in task execution (Spielberg et al., 2008). The activation of the left middle frontal gyrus corresponds to the approaching motivation, and the activation of the right middle frontal gyrus corresponds to the avoidance motivation. Finally, intergroup comparison can also trigger stronger emotional involvement and activate related brain areas, such as the superior frontal gyrus (Kuchinke, 2005; Wegrzyn, 2017).

### 1.3 Hypothesis

Based on this, although there is no direct research on the cognitive mechanism of social comparison in intergroup situations, we can still make assumptions with reference to theories and relevant evidence.

In intergroup situations, social comparison among individuals may lead to goal-oriented motivation and more emotional involvement. Therefore, the downward comparison will trigger positive emotions as a reward, while the upward comparison will harm the individual’s self-esteem and self-efficacy, and activate the relevant brain areas. Such as the middle and upper frontal gyrus.

On the other hand, in intragroup situations, social comparison among individuals may trigger self-reference cognition. Therefore, the downward comparison will make individuals embarrassed and reduce self-efficacy, while upward comparison will make individuals feel "common prosperity". The precuneus, fusiform gyrus and other relevant brain regions may be activated during this process.
2. Method

2.1 Ethics statement

This study has been approved by the IRB at Southwest China University. We had obtained appropriate ethics committee approval for the research reported, and all subjects gave written informed consent in our experiment. The study was approved by Southwest University Brain Imaging Center Institutional Review Board in accordance with the Declaration of Helsinki (1991).

2.2 Subjects

Twenty six right-handed, healthy students from the Southwest China University participated (17 male and 9 female; aged between 18 and 26 years, with a mean age of 21.62 years) in our experiment. Each subject is a League of Legends gamer, and still plays regularly every week. None of the subjects had ever played Honor of Kings or had no experience in playing within six months. The average time to play the game is 1.81 hours per weekday, while 3.23 hours per weekend. In order to ensure the group identity level of the subjects, each subject filled in the organizational identification scale for the League of Legends players and scored more than half of the total score (mean score = 21.46). All of the subjects provided a written informed consent. The subjects did not suffer from past neurological or psychiatric illnesses, but have normal or corrected-to-normal vision.

2.3 Experimental procedure

The design was a 2 (comparison target; within-group - out-group) × 3 (comparison outcome; upward - downward - control) in-subjects factorial design.

The subjects were told that the purpose of our experiment was to explore the difference of responding ability and potential intelligence between the players of League of Legends (LoL) and Honor of Kings (HoK). LoL is a Multiplayer Online Battle Arena (MOBA) game, which has been operating on the computer platform for more than ten years and has a certain popularity. HoK is a popular mobile game with a huge player base and similar game mechanics to LoL.

In the formal experiment, they need to carefully observe the dot matrix on the screen and make a series of judgments, while the test program requires two players to perform at the same time through real-time connection network. subjects were told the total score of the two players will be included in their respective player group database after the task is completed, so that we can compare which side is more competent. The outcome of each judgment is based on two criteria: (1) the accuracy of the subject’s response; (2) the mean reaction time (RT) of another group of college students who had previously participated in the experiment. For example, the subject won this round of judgment when making responses correctly and faster than the mean RT; the subject failed this round of judgment when making responses incorrectly or correctly but slower than the mean RT. In a word, the subjects were required to complete each judgment as quickly and accurately as possible.

Each subject needed to take two rounds of tests, and was told that because the number of LoL players is relatively small, he will take tests with one LoL player and one HoK player successively. Unbeknownst to the subjects, the other two players was nonexistent. There was no real-time connection network, and all subjects completed the experiment independently. In order to avoid the unexpected influence of competitive attitude on the experimental results, they were told that their scores have nothing to do with the remuneration they receive, but only a reference of his group’s ability and intelligence.

During the dot estimation task, the subjects were seated comfortably in a chair with their eyes approximately 75 cm from the computer monitor. As illustrated in Figure 3, before each part of the task, a 4 s “connecting” screen was presented, followed by a 6 s “paring with player of LoL” or “paring with player of HoK” screen, which indicated that the subjects performed the task with a player who have a same or different group identity. To increase immersion, we also added game icons and random numbers to highlight each other’s
identity information. The order of pairing with the same or different group identity player was counterbalanced across subjects. Each trial began with a white fixation cross presented on a black background for 500 ms and followed by the random dot pictures created with MATLAB 2019b (i.e., 30 white dots randomly distributed on a black background for a duration of 1,500 ms). With a random integer number in the range of 27–33 on the screen, the subjects were asked to decide whether they saw more or fewer dots than the presented number. The subjects were subsequently instructed to judge whether the number of white dots was higher or lower than the numerical figure by pressing key ‘1’ or ‘2’, respectively, on the fMRI keyboard by using the right hand. After pressing the key, the subject saw their choice on the screen for 500 ms, then the outcome occurred in a vertical arrangement. The scores of the subjects will be displayed in the red box above, while the scores of the opponents will be displayed in the blue box below. The subjects were informed of the four types of outcomes based on their respective responses: “+5/-5,” “-5/+5,” “+5/+5,” and “-5/-5,” indicating “self-gain versus other-loss” (GL), “self-loss versus other-gain” (LG), “self-gain versus other-gain” (GG), and “self-loss versus other-loss” (LL). The first two results represent downward comparison and upward comparison, while the other two results are control group.

After the result displayed for 2s, the next trial started. Unbeknownst to the subjects, all the outcomes were presented randomly, and each subject received each type of outcome an equal number of times.

![Illustration of a single trial of the dot estimation task](image)

### Figure 3 Illustration of a single trial of the dot estimation task

Each part of the experiment consisted of two blocks of 128 trials, and each outcome feedback consisted of 32 trials. Before the formal experiment, subjects were required to practiced the task for eight trials, two trials per condition, to make sure they were familiar with the process and stimulus meaning. The entire task lasted 20 to 30 min. After all the trials, subjects were required to answer several questions about emotion experience elicited by each outcome feedback (five-point scale, 1 = not at all, 5 = extremely): (1) How happy were you when you gained score and the LoL(HoK) player lost it? (2) How disappointed were you when you lost money and the LoL(HoK) player gained it? (3) How happy were you when you and the LoL(HoK) player both gained money? (4) How disappointed were you when you and the LoL(HoK) player both lost money?

After the experiment, each subject received a reward of 60 yuan. All subjects were asked about the credibility of the scenario in which they were paired with a within-group and an out-group player to complete the task, and no one raised any doubts. No one doubted the true purpose of the experiment. The experiments were conducted using E-Prime 2.0 (PST, Inc., Pittsburgh, PA, USA) for stimulus presentation and behavioral data acquisition.
2.4 fMRI acquisition

A 3-T Trio scanner (Siemens) and an eight-channel phased array coil were used to acquire high-resolution T1-weighted structural images (1 mm×1 mm×1 mm) for anatomical localization and T2*-weighted echo planar images (32 slices, 3 mm×3 mm×3 mm voxels, TR = 2000 ms, TE = 30 ms, flip angle = 90°, FOV = 192 mm×192 mm), slice gap = 0.6 mm).

2.5 Data analysis

Statistical analysis of the scale data was completed by SPSS21.0 while the fMRI data analysis was performed using SPM12 software from the Wellcome Department of Cognitive Neurology, London which is implemented on MatLab9.7.0 R2019b (MathWorks, Natick, MA). All the analysis was started from the appearance of the outcome feedback. DPABI (Data Processing and Analysis For Brain Image, http://rfmri.org/dpabi) software was used to pre-process fMRI (functional magnetic resonance imaging) data. Scans were started from slice time corrected, then realigned, normalized into standard Montreal Neurological Institute (MNI) space via 12-parameter affine transformation, finally, all data were smoothed with an 8mm full width at half maximum (FWHM) Gaussian kernel. After preprocessing, statistical analyses for each individual subject were based on the fixed-effects general linear models (GLM) and analyses on the level of the group were based on random-effects models.

The resulting images had cubic voxels of 3×3×3 mm. The BOLD responses were modeled as events convolved with the canonical hemodynamic response function in SPM12. For each condition (out-group GL/LG/GG/LL; within-group GL/LG/GG/LL), all trials were averaged to estimate BOLD responses.

In the group random effects (second-level) analysis, subject-specific linear contrasts of these parameter estimates were entered in a series of paired t-tests, each constituting a group-level statistical map. Our main contrasts of interest were BOLD signal in response to assess the main effect of conditions between within-group and out-group. This contrast was used to identify the reward-sensitive regions of the brain. The p-value for MRI data was set as < 0.001 (GRF corrected for multiple comparisons, with voxel p < 0.001; cluster p < 0.05; two tailed).

3. Result

3.1 Subjective ratings

Table 1 shows the subjects’ emotional rating scores for four types of outcome feedback. We used the paired-sample t test to compare the subject’s emotional experience when it was intragroup comparison and intergroup comparison for each type of outcome. The results showed that the subjects were happier when gaining score in the context of intergroup than of the within-group losing out ( p < .001), while the same phenomenon occurred when gaining score with the within-group player than gaining score with the out-group player ( p < .05). However, when self losing score, we found no significant difference between the disappointment that came from the within-group player gaining and the out-group player gaining. We also found no significant difference between the disappointment caused by losing score with the within-group player and losing score with the out-group player. These results suggested that when the subjects’ own outcomes differed from the others’ outcomes, comparing with the intragroup comparison situation, the intergroup comparison situation was more likely to elicit a strong emotional experience for the subjects.

<table>
<thead>
<tr>
<th>Outcome feedback</th>
<th>Intragroup</th>
<th>Intergroup</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-gain—Other-loss (Happiness)</td>
<td>4.04±0.60</td>
<td>4.35±0.69</td>
<td>-3.33</td>
<td>0.003</td>
</tr>
<tr>
<td>Self-loss—Other-gain (Disappointment)</td>
<td>3.73±0.83</td>
<td>3.92±1.09</td>
<td>-1.31</td>
<td>0.203</td>
</tr>
<tr>
<td>Self-gain—Other-gain (Happiness)</td>
<td>3.42±0.90</td>
<td>2.92±0.94</td>
<td>2.17</td>
<td>0.040</td>
</tr>
<tr>
<td>Self-loss—Other-loss (Disappointment)</td>
<td>3.15±0.93</td>
<td>2.88±0.95</td>
<td>1.43</td>
<td>0.166</td>
</tr>
</tbody>
</table>
Table 1 Subjective ratings of emotional experience (M ± SD) for four types of outcome feedback in intragroup and intergroup comparisons

3.2 Functional Brain Activity

One subject was excluded from the first- and second-level analysis because the head movement amplitude was greater than 2.5mm. Among the remaining 25 subject, the difference of brain activation between upward and downward comparison is discussed in the dimension of group identity.

Table 2 shows the brain regions activation of downward comparison(GL) versus upward comparison(LG) in intragroup social comparison.

<table>
<thead>
<tr>
<th>Brain region</th>
<th>H</th>
<th>CS</th>
<th>MNI Coordinates</th>
<th>T max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fusiform gyrus</td>
<td>R</td>
<td>154</td>
<td>-36 -45 -6</td>
<td>5.5199</td>
</tr>
<tr>
<td>Putamen/Lentiform Nucleus</td>
<td>R</td>
<td>145</td>
<td>24 3 15</td>
<td>6.4962</td>
</tr>
<tr>
<td>Precuneus</td>
<td>R</td>
<td>146</td>
<td>21 -81 21</td>
<td>4.7333</td>
</tr>
<tr>
<td>Precentral Gyrus</td>
<td>R</td>
<td>1228</td>
<td>30 -21 63</td>
<td>7.4781</td>
</tr>
</tbody>
</table>

H = hemisphere; R = right; L = left; CS = cluster; MNI = Montreal Neurological Institute.

Table 2 Brain regions activation of intragroup Downward vs. Upward comparison
(GrF corrected; voxel $p < 0.001$; cluster $p < 0.05$)

As we can see, downward comparison significantly activated the fusiform gyrus, putamen, lentiform nucleus, precuneus and precentral gyrus compared with upward comparison. Figure 4 shows the cluster significantly activated in this comparison.

Figure 4 Cluster significantly activated in downward comparison compared with upward comparison in intragroup context
(with GRF correction, voxel level $p <0.001$, cluster level $p <0.05$)

Table 3 shows the brain regions activation of downward comparison(GL) versus upward comparison(LG) in intergroup social comparison.
Table 3 Brain regions activation of intergroup Downward vs. Upward comparison

(GrF corrected; voxel p < 0.001; clusterp < 0.05)

As the table shown, compared with upward comparison, downward comparison significant activated the angular gyrus, superior frontal gyrus and middle frontal gyrus. Figure 5 shows the cluster significantly activated in this comparison.

<table>
<thead>
<tr>
<th>Brain region</th>
<th>H</th>
<th>CS</th>
<th>MNI Coordinates</th>
<th>T max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular gyrus</td>
<td>R</td>
<td>528</td>
<td>-48</td>
<td>30</td>
</tr>
<tr>
<td>Superior Frontal Gyrus</td>
<td>R</td>
<td>128</td>
<td>33</td>
<td>51</td>
</tr>
<tr>
<td>Middle Frontal Gyrus</td>
<td>R</td>
<td>448</td>
<td>39</td>
<td>18</td>
</tr>
</tbody>
</table>

H = hemisphere; R = right; L = left; CS = cluster; MNI = Montreal Neurological Institute.

Figure 5 Cluster significantly activated in downward comparison compared with upward comparison in intergroup context

(with GrF correction, voxel level p < 0.001, cluster level p < 0.05)

The comparison results of the activation of the other brain regions were not statistically significant, so they will not be shown and discussed here.

4.Discussion

This may be the first research to discuss the neural mechanism of social comparison modulated by group identity through fMRI. We used functional magnetic resonance imaging to explore the neural mechanism of social comparison among game players, and found that after controlling the direction of social comparison, the activation of brain areas will be affected by the group identity of the comparison object.

In our introduction, we set up two theoretical models. The first model assumes two paths for online games to trigger problem games, and the social interaction path has been verified in our experiment. Different group identities lead to different cognitive processes in the social comparison of players, and among them, the downward comparison in within-group contexts can generate positive emotions and reward brain activation, which is similar to positive reinforcement. This finding means that social comparison has a potential impact on the players’ continuance intention and behavior.
Our second model believes that, inspired by social information, social comparison is divided into two parts: "self classification" and "dimension division". Different identity information will trigger similarity or dissimilarity testing, and produce assimilation or contrast effects. In our experiment, the model has been verified. In the same context of downward comparison, the subjects produced significantly different brain area activation in the face of within-group objects and out-group objects. This finding proves that the group identity of players has a moderating effect on their social comparison.

4.1. Intragroup Comparison

In the intragroup comparison, downward comparison significantly activated fusiform gyrus, putamen, lentiform nucleus, precuneus, and precentral gyrus compared with upward assimilation. This result partially supports our hypothesis that when players compare themselves with a within-group player, downward comparison not only induces self-reference and embarrassment as expected, but also activates reward-related brain regions.

Thereinto, the activation of fusiform gyrus indicated the cognition of identity and arousal of preference. The fusiform gyrus, especially the right fusiform gyrus, plays an important role in the recognition of identity (Koyama & S., 2014). At the same time, it is related to the subjective evaluation of positive stimuli and the activation of preference. The results of fMRI showed that the activation of bilateral fusiform gyrus increased with the increase of preference scores (Vartanian & Goel, 2004).

Secondly, the results also show the activation of the putamen. Previous experiments conducted by researchers have confirmed that the putamen is mainly involved in processing visual and reward information in complex tasks (Vicente et al., 2012). The neural association of stimulus-action-reward also exists in the putamen (Haruno & Kawato, 2006). In addition, the lentiform nucleus, as a brain region related to the brain reward system (Wang, Zhang, & Jia, 2019), also produced significant activation in this comparison. The activation of fusiform gyrus, putamen and lentiform in our experiment shows that although downward comparison with a within-group player may reduce self-evaluation theoretically, it is still a reward outcome objectively.

As a part of the superior parietal lobule, the precuneus is related to positive emotions (An et al., 2018; Ken-ichi, 2015), high-level cognitive functions (Petrini, 2014) and self reference (Shinpei et al., 2009; Sul, Choi, & Kang, 2012). Material stimuli related to self representation can produce greater activation of precuneus (Lian, Ajay, & Matthew, 2010). In a recent study, interestingly, Guendelman also found that social emotion regulation can lead to significant precuneus activation (Guendelman et al., 2022). When individuals regulate the emotions of others exposed to aversive stimuli, for example, the precuneus will be activated. Although there is no evidence that the precuneus plays a specific role in social comparison, we can infer it from the identity of the members of the same group. On the one hand, the performance of group members serves as a reference to our own abilities, stimulating the cognitive process of self-reference. On the other hand, when seeing the poor performance of a same group player, it may also make individuals have the intention of social emotion regulation.

Finally, the results show the activation of the precentral gyrus. In addition to common motor functions (Yousry, 1997; Sanes et al, 1995), the precentral gyrus was found to be associated with emotions (Kolesar, Kornelsen, & Smith, 2017), such as shame (Bastin, 2021). At the same time, some studies have found that it is related to facial expression recognition (Jiang et al., 2012). Morita pointed out that the activation of the right precentral gyrus reflected the conscious characteristics of self observation through the face scoring experiment (Morita et al., 2008). The higher the degree of embarrassment of your face photo, the stronger the activation level. In our experiment, downward comparison with a within-group player activated the precentral gyrus, which not only proved the arousal of shame and embarrassment, but also showed that this arousal was related to self reference.

Previous research on assimilation effect shows that downward assimilation will reduce self-efficacy (Collins & Rebecca, 1996). Based on the self-classification theory and the selective accessibility model, we believe that intragroup social comparison produces assimilation effects. Therefore, we assume that the intragroup
downward comparison may be related to the generation of negative emotions. However, the results showed that it still produced the activation of reward related brain regions. This may prove that even if the assimilation effect is a phenomenon of self-evaluation towards comparative goals, the better performance of oneself will still be processed into reward results in the cognitive process, regardless of its dimensions.

4.2. Intergroup Comparison

In the intergroup comparison, relatively, downward comparison significantly activated angular gyrus, middle frontal gyrus and superior frontal gyrus compared with upward comparison. This result supports our hypothesis well that when player compare themselves with an out-group player, downward comparison not only activated the brain regions related to positive feedback, but also aroused the individual’s positive emotions and goal oriented cognition.

Angular gyrus is a cross modal hub, where gathered multisensory information is combined and integrated to understand events and give meaning, manipulate psychological representations, solve common problems, and redirect attention to relevant information. It can also give meaning to external events according to stored memories and previous experiences (Seghier & M., 2013). In addition, Sakaki found through experiments that, compared with negative pictures, after viewing positive pictures, the subjects’ angular gyrus was significantly activated (Sakaki & Niki, 2011). The activation of this brain region in our study shows the positive valence of this kind of outcomes on individuals.

The middle frontal gyrus is considered to be able to coordinate goal oriented behavior (Liljeholm et al., 2011) and response to external events. In top-down control, it guides the behavior to conform to the motive goal (Elton & Gao, 2015). At the same time, Spielberg’s research pointed out that the activation of bilateral middle frontal gyrus is related to the type of state motivation used in task execution (Spielberg et al., 2008). The activation of the left middle frontal gyrus corresponds to the approaching motivation, and the activation of the right middle frontal gyrus corresponds to the avoidance motivation. In our study, the activation of the middle frontal gyrus confirmed that the outcomes of downward comparison with an out-group player were consistent with individual motivation goals.

The superior frontal gyrus is also activated. Positive feedback can activate this brain region more strongly than negative feedback (Nieuwenhuis et al, 2005), and it is also closely related to emotional valence. Kuchinke found that words with positive emotional valence can significantly activate bilateral superior frontal gyrus compared with negative emotional valence (Kuchinke et al., 2005). Wegrzyn further confirmed that active processing of the emotional valence of words can increase the activation of the right superior frontal gyrus (Wegrzyn et al., 2017). The activation of the superior frontal gyrus proves that the downward comparison with an out-group player is not only a reward stimulus with positive valence objectively, but also a positive emotional valence subjectively.

4.3. General Discussion

Whether it is intragroup or intergroup comparison, downward social comparison has triggered reward and positive results related brain regions. Previous studies have found that objective performance and subjective evaluation have an interactive effect on emotion (Daniels, L., 2019). Objectively good performance does not necessarily bring satisfaction, which also depends on the subjective evaluation of individual performance. This may prove that the subjects’ perception of self leadership is objective, but it does not interfere with the subjective impact on emotion and self-efficacy, which is regulated by the social comparison dimension. The cognitive processing of the direction and dimension of social comparison is relatively independent.

Although several studies have documented that how directions of social comparison trigger brain regions related with reward or negative emotions (Fliessbach et al., 2007; Du et al., 2017; Liu, Hu, & Mai, 2021), we have not found that any study also considers the impact of group comparison situations or social comparison dimensions.
We consider the social comparison frequently occurring in online game players’ game behaviors and the group division situation, and discuss the differences in brain activation caused by social comparison in different situations. The result showed that although the downward comparison within the group activated the reward processing, it also triggered negative emotions and self-reference. In contrast, the downward comparison outside the group directly activated the positive emotion and goal-oriented motivation.

This finding proves that the behavior of comparing with the out-of-group individuals inside and outside the game may increase the player’s willingness to continue playing as a reinforcement stimulus. The social comparison with the heterogeneous object in subjective cognition may further stimulate the player’s achievement motivation, thus leading to his willingness to continue the game. At the same time, because our subjects are not individuals with game addiction, the results can be widely promoted and have certain ecological validity.

It is worth mentioning that we conducted a statistical analysis of the subjective rating scores of the subjects. The paired-sample t test results of emotion experience showed that individuals perceived significantly greater happiness when the other person was an out-group player in the same situation in which they scored and the other person lost. Similar differences occurred in situations where both individuals scored, with individuals reporting significantly higher happiness when the other was a within-group player. As an old Chinese saying goes, “lips are dead and teeth are cold”. The failure or misfortune of similar or identical individuals often does not bring positive feedback. A previous study found that individuals’ empathy for pain to others is within-group favoritism under the general social group condition or minimal group condition (Han & Shihui, 2018). At the same time, although not reflected in the questionnaire data, previous studies have found that when out-group individuals surpass themselves, individuals will make more efforts (Lount & Phillips, 2007), which implies that upward contrast may pose a threat to individual self-efficacy. All these evidences show that there are different cognitive processing modes in social comparison in different situations.

We modified the dot estimation paradigm, activated and discussed the activation of players’ brain regions in different social comparison situations by manipulating the group identity and relative size of subjects and opponents. Theoretically, Our study discusses the moderating effect of within-group division on social comparison based on functional MRI evidence. The results of the experiment demonstrate the assimilation effect and contrast effect from the side. Both effects objectively activated reward and positively stimulated relevant brain regions. We further found that the downward comparison with a within-group object was more likely to trigger the activation of brain regions related to self reference, shame and embarrassment, while leading to the activation of brain regions related to positive emotion and goal oriented behavior when the downward comparison occurs in intergroup comparison. This discovery broadens the understanding of the cognitive mechanism of social comparison, and is helpful for the further exploration of related research in the future.

In terms of practice, our research has proved that when game players make social comparison with other groups, they will trigger a strong level of emotional involvement and motivation, and the result of downward comparison will further improve their continued playing behavior. This discovery provides a new perspective for the cause of IGD. At the same time, setting up different social comparison situations and guiding addictive players to conduct specific social comparison may help psychologists to intervene more effectively.

4.4. Limitations

Although our study innovatively explores the neural mechanism of social comparison in the context of group division while ensuring reliability and validity, there are still some limitations that should be noted. First of all, our data analysis only found the difference between two kinds of downward comparison. However, there should also be behavioral and cognitive differences between the two in the opposite direction. We believe that this may be because the influence of upward comparison on individuals will be regulated by such factors as self-esteem and personality traits. A recent study found self-esteem moderated the relationship between upward social comparative sensitivity and emotional exhaustion (Hui et al., 2022). For individuals with low optimism, upward social comparison is also more likely to lead to depressive symptoms (Liu et al., 2017). Therefore, the control of relevant variables can be considered in future research.
Secondly, in order to ensure the effectiveness of group division, we conducted an organizational identity test on LoL players participating in the experiment. However, we only controlled their experience of playing HoK, but did not do further identification testing. Future research can consider controlling the subjects' sense of identity and rejection of the target group, so as to avoid the impact of emotional evaluation on the results.

Finally, the research paradigm needs to be further optimized. The paradigm we adopted is a variation of the dot estimation paradigm first used by Fliessbach in 2007, which was originally used to explore the cognitive mechanism of social comparison in different directions. With the extension of the research content, we urgently need a paradigm that can simultaneously take into account the direction and dimension of social comparison. It is expected that future researchers can use a more effective paradigm to study the different effects of social comparison.

Conclusion

This study explored the neural mechanism of social comparison between players in different situations through fMRI and point estimation paradigm.

We found that the downward comparison led to significantly different brain activation compared with the upward comparison. The fusiform gyrus, putamen, lentiform nucleus, precuneus and precentral gyrus were significantly activated when the group identity of the comparison object was the same as that of the player. When the two have different identities, downward comparison significantly activated the angular gyrus, middle frontal gyrus and superior frontal gyrus.

Our research has proved that group identity has a moderating effect on social comparison cognitive process among players. When the object of downward comparison is an out-group member, the player will receive the reward information and positive emotional valence, which can positively predict their continuous game behavior in theory.

This study provides a new possibility for the cause of game addiction at the perspective of neural mechanism.

Reference

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H = hemisphere; R = right; L = left; CS = cluster; MNI = Montreal Neurological Institute.

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H = hemisphere; R = right; L = left; CS = cluster; MNI = Montreal Neurological Institute.