Self-Referential Information Processing Advantage: Evidence from the Attentional Orienting Network (Postprint)

Authors: Gao Hong, Li Yangzhuo, butterfly, Zhu Min, Gao Xiangping, Hu Tianyi

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Abstract

The study employed the Attention Network Test (ANT) to examine differences in processing efficiency of self-related information across the alerting, orienting, and executive control networks of attention, with the aim of revealing the attentional mechanisms underlying the advantage in self-information recognition. Experiment 1 investigated differences in processing efficiency for face type (self-face or other-face) across the three attention networks; Experiment 2 utilized a self-association learning paradigm to validate the findings of Experiment 1; Experiment 3 employed color type (red or green) as the target stimulus and face type as the background to examine whether task-irrelevant self-information influences processing efficiency in attention networks. The results revealed that when self-information served as the target, individuals exhibited a processing efficiency advantage in the attentional orienting network, whereas no differences in processing efficiency were observed in the alerting and executive control networks. When self-related information was task-irrelevant, no processing efficiency advantage was demonstrated in any of the alerting, orienting, or executive control networks of attention. These findings indicate that the attentional advantage for self-information occurs specifically in the orienting network and is modulated by task priority.

Full Text

Cognitive Advantage for Self-Information: Evidence from the Orienting Network of Attention

GAO Hong[1], **LI Yangzhuo**[1], **HU Die**[1], **ZHU Ming**[2],[3], **GAO Xiangping**[1], **HU Tianyi**[1]

[1]Department of Psychology, School of Education, Shanghai Normal University, Shanghai 200234, China
[2]Department of Social Work and Management, Nanjing Tech University, Nanjing 211816, China
[3]Institute of Social Innovation and Development, Nanjing Tech University, Nanjing 211816, China

Abstract

This study employed the Attention Network Test (ANT) to examine processing efficiency differences for self-related information across the three attention networks—alerting, orienting, and executive control—to elucidate the attentional mechanisms underlying the self-information recognition advantage. Experiment 1 investigated processing efficiency differences for face type (self-face vs. other-face) across the three attention networks. Experiment 2 used a self-association learning paradigm to replicate Experiment 1. Experiment 3 examined whether task-irrelevant self-information affects attention network processing efficiency by using color type (red or green) as the target stimulus and face type as the background. The results revealed that when self-information served as the target, individuals showed a processing efficiency advantage in the orienting network, but not in the alerting or executive control networks. When self-related information was task-irrelevant, no processing efficiency advantage emerged in any of the three attention networks. These findings demonstrate that the attentional advantage for self-information occurs specifically in the orienting network and is modulated by task priority.

Keywords: self-related information; attention network test; alerting; orienting; executive control

Introduction

The perceptual processing advantage for self-information has been well-documented across numerous studies. The earliest research on this phenomenon can be traced to the "cocktail party effect," which refers to the ability to easily detect and recognize one' s own name even under strong interference conditions (Moray, 1959). Recent studies have demonstrated that individuals can identify their own faces more quickly (Tong & Nakayama, 1999; Pannese & Hirsch, 2010; Zhu, Hu, Tang, Luo, & Gao, 2015) and that self-faces produce stronger interference effects on target stimuli than other faces (Devue & Brédart, 2008). Using eye-tracking technology, Devue, Van der Stigchel, Brédart, and Theeuwes (2009) required participants to search for a specific mouth shape (pronouncing "O" among mouths pronouncing "M") in presented faces without explicitly identifying the faces themselves. The results showed that reaction times for self-faces and familiar faces were longer, with total fixation durations significantly exceeding those for stranger faces. Moreover, when self-faces and familiar faces served as targets (the "O" mouth shape), fixation durations were longer than when they served as distractors (the "M" mouth shape), indicating that self-information attracts more attention when it shares features with the target, and that attention is difficult to disengage once directed toward self-information. Self-information has also demonstrated processing advantages in electrophysiological and functional imaging measures. For instance, ERP studies have found that self-faces elicit larger P300 amplitudes than familiar other faces (Ninomiya, Onitsuka, Chen, Sato, & Tashiro, 1998). Using functional neuroimaging, Sui, Rotshtein, and Humphreys (2013) found that self-associated shapes enhanced neural activity in the ventromedial prefrontal cortex (vmPFC), which is involved in self-representation, and the left posterior superior temporal sulcus (LpSTS), which is associated with social attention, compared to other-associated shapes. Furthermore, the connectivity strength between vmPFC and LpSTS could predict the magnitude of the self-association advantage.

These studies consistently demonstrate that individuals exhibit attentional processing advantages for self-information, which may be attributed to attentional orienting (rapidly shifting attention to self-related information), stability (maintaining attention on self-information for longer durations), and allocation (prioritizing limited attentional resources to self-related processing). However, the specific mechanisms underlying this attentional advantage remain unclear. Does self-information processing advantage involve specific attention networks? Previous research has often treated attention as a unitary cognitive resource system, with dependent measures reflecting overall performance outcomes. To better understand the attentional mechanisms of self-information processing advantages, it is necessary to examine attention as a system comprising distinct functional components.

Based on cognitive neuropsychological research, Posner and Petersen (1990) proposed that attention could be conceptualized as three functionally and neuroanatomically distinct networks: alerting, orienting, and executive control. The alerting network reduces temporal uncertainty about upcoming stimuli, promoting vigilance, and is implemented through thalamic and parietal regions, particularly in the right hemisphere, including the dorsolateral prefrontal cortex (DLPFC), anterior cingulate cortex (ACC), anterior insula (AI), right inferior frontal gyrus (IFG), and intraparietal sulcus (IPS) and surrounding areas (Fan, Mccandliss, Fossella, Flombaum, & Posner, 2005; Gao et al., 2013; Wang, Zhao, Gui, & Chen, 2016). The orienting network directs attention to spatial locations relevant to target stimuli before their appearance, reducing spatial uncertainty and prioritizing specific information inputs, and is associated with the frontoparietal system (Tang, Wu, & Shen, 2016). The executive control network monitors and resolves conflicts, enabling individuals to inhibit prepotent responses and complete tasks according to goal demands (Petersen & Posner, 2012), with the ACC, DLPFC, and frontal eye field (FEF) serving as primary brain regions for this function (Xuan et al., 2016). Numerous studies have confirmed that these three attention networks operate independently, with neuroimaging research demonstrating that the three functional networks can function separately to support different attentional components and their interactions (Fan, McCandliss, Sommer, Raz, & Posner, 2002; Mackie, Dam, & Fan, 2013; Visintin et al., 2015).

To calculate processing efficiency across the three networks, Fan et al. (2002) designed the Attention Network Test (ANT). In the classic ANT task, participants must quickly and accurately judge the direction (left or right) of a central arrow and respond with a button press. Cue types include four conditions: spatial cue (an asterisk appearing at the target location), central cue (an asterisk at fixation), double cue (two asterisks appearing above and below fixation where targets may appear), and no cue (fixation remains unchanged). Central and double cues serve as alerting signals indicating that a target will appear soon but not specifying its location, whereas spatial cues provide both alerting information and precise location information. Thus, the ANT combines a cued target task with a flanker task, enabling measurement of alerting and orienting efficiency through different cueing conditions, while the flanker task measures executive control efficiency. The ANT’ s primary advantage lies in its ability to simultaneously assess the efficiency of orienting, alerting, and executive control within a simple cued reaction task. Operational definitions for the three attention networks are: alerting = RT_{no} cue -RT_{double} cue (larger values indicate higher alerting efficiency); orienting = RT_{central} cue -RT_{spatial} cue (larger values indicate higher orienting efficiency); executive control = RT_{incongruent} -RT_{congruent} (incongruent flanker conditions introduce conflict; larger values indicate lower executive control efficiency and longer conflict resolution time). The ANT’ s convenience and validity have led to its widespread application in genetic studies of attention networks, research on conflict resolution mechanisms in bilingual versus monolingual participants, and assessment of attentional functions in various clinical populations with attentional deficits, including brain injury, stroke, schizophrenia, depression, and ADHD (Kratz et al., 2011).

Although some studies have demonstrated differential processing efficiency for attention networks across different visual stimuli—for example, Federico, Marotta, Adriani, Maccari, and Casagrande (2013) found that processing faces, as typical social stimuli, differed from processing simple geometric shapes, showing decreased alerting efficiency but enhanced orienting and executive control efficiency—these studies could not determine whether differences in attention network efficiency between faces and simple shapes resulted from physical features or social meaningfulness. Examining stimuli with similar physical features but different intrinsic meanings provides a clearer test of whether stimuli with different social significance produce differential processing in attention networks.

In summary, the present study adopted the ANT task, replacing arrows with real faces, and conducted three experiments to examine whether self-information processing exhibits specificity across the three attention sub-networks. Experiment 1 used face type (self-face or other-face) as the target stimulus to investigate processing efficiency differences between self-faces and other-faces across the three attention networks. Experiment 2 employed a self-association learning paradigm to replicate Experiment 1 while controlling for familiarity effects. Experiment 3 used stimulus color (red or green) as the target stimulus with faces as irrelevant backgrounds to examine how task relevance affects the processing efficiency of self-related information in attention networks.

Experiment 1: Processing Efficiency of Self-Information in the Three Attention Sub-Networks–Self-Face as the Response Target

Participants

Twenty-eight undergraduate and graduate students (12 male, 16 female) participated in the experiment. Participants ranged in age from 19 to 28 years (M = 22.29, SD = 2.55), were all right-handed, had normal or corrected-to-normal vision, and no color blindness. Participants received monetary compensation after completing the experiment.

Materials

To avoid familiarity effects on self-face recognition, participants' acquaintance faces were used as other-face stimuli to minimize familiarity differences between self-faces and other-faces. All participants completed the experiment in pairs, with each participant and their same-sex friend having known each other for at least one year. Photographs were taken individually.

Face photo acquisition and processing: High-resolution frontal face photographs with neutral expressions were taken using a digital camera before participants entered the laboratory. Adobe Photoshop CS6 was used to process the photos, cropping the facial area from the top of the head to the chin. Each face photo was saved as a 1.6° × 2.1° grayscale JPG image file with consistent brightness, contrast, and spatial frequency. At the beginning of each trial, a white cross (1° × 1°) served as the central fixation point. A white asterisk (1.5° × 1.5°) functioned as the cue stimulus: for central cues, the asterisk covered the central fixation point; for double cues, asterisks appeared simultaneously above and below the central fixation point; for spatial cues, the asterisk appeared at the location where the target stimulus would appear (either above or below the central fixation point); for no-cue trials, no asterisk appeared and the cross fixation remained on screen. The target stimulus was a face image (self or friend) presented at the center of the screen, with flanker stimuli appearing on both sides of the target as two face images on each side. For congruent flanker trials, flanker stimuli matched the target stimulus (five identical face images); for incongruent flanker trials, flankers differed from the target stimulus (the central face differed from the flanking faces). Each face image was separated by 0.1°, and the five face images formed a stimulus array measuring 8.4° × 2.1°, presented 1° above or below the fixation point. The experiment was programmed and data were collected using E-Prime 2.0. The experimental apparatus consisted of a Dell computer with a 17-inch ViewSonic monitor with a resolution of 1024 × 768 and a vertical refresh rate of 85 Hz. The screen background color was gray (RGB: 128, 128, 128) with a luminance of 210 cd/m^2.

Design

The experiment employed a within-subjects design with three factors: target type (self-face, friend face) × cue type (no cue, central cue, double cue, spatial cue) × flanker type (congruent, incongruent).

Procedure

Participants completed the experimental task individually in a dimly lit, quiet room, seated approximately 60 cm from the display. Each trial began with a central fixation cross "+" presented for a random duration between 400 and 1600 ms. This was followed by a 150 ms cue stimulus indicating that the target would appear soon. Cue types included four conditions: for central cues, the asterisk covered the central fixation point; for double cues, asterisks appeared simultaneously above and below the central fixation point; for spatial cues, the asterisk appeared at the location where the target stimulus would appear (either above or below the central fixation point); for no-cue trials, no asterisk appeared. After the cue disappeared, the central fixation cross remained for an additional 400 ms. The target and flanker stimuli then appeared randomly above or below the fixation point. Participants used their right index and middle fingers to press the "b" and "n" keys to judge the identity of the central target face as "me" or "not me" (response mapping was counterbalanced across participants), without responding to the flanker stimuli. The stimuli disappeared upon response or after 1700 ms if no response was made. Following stimulus offset, only the fixation cross remained for an inter-trial interval ensuring a constant trial duration of 4000 ms. Participants were instructed to maintain attention on the central fixation point throughout the experiment and respond to target stimuli as quickly and accurately as possible.

Before the formal experiment, participants completed 16 practice trials with feedback to familiarize themselves with the task. The formal experiment consisted of two blocks, each containing 96 trials, with no feedback provided during the formal experiment. Participants rested for 2–3 minutes between blocks. The entire experiment lasted approximately 20 minutes. The trial sequence is illustrated in Figure 1 [Figure 1: see original paper].

Results

Trials with incorrect responses, reaction times shorter than 200 ms or longer than 1200 ms (Federico et al., 2013; Callejas, Lupiàñez, Funes, & Tudela, 2005) were excluded from analysis (accounting for 5.17% of all data). Data were analyzed using SPSS 19.0.

Table 1 presents participants' mean reaction times and accuracy rates across conditions. Repeated measures ANOVA on reaction times revealed a significant main effect of target type, $F(1, 27) = 45.75$, $p < 0.001$, $^2 = 0.63$ (M_{self} = 645 ± 53 ms, M_{friend} = 683 ± 52 ms). The main effect of cue type was also significant, $F(3, 81) = 72.29$, $p < 0.001$, $^2 = 0.73$. Post-hoc comparisons showed that spatial cue trials (617 ± 58 ms) were significantly faster than the other three cue types, double cue (663 ± 54 ms) and central cue (673 ± 55 ms) were both significantly faster than no cue (705 ± 48 ms, all $ps < 0.001$), and double cue was faster than central cue, $p = 0.037$. The main effect of flanker type was significant, $F(1, 27) = 27.89$, $p < 0.001$, $^2 = 0.51$, with incongruent flanker trials (672 ± 51 ms) showing significantly longer reaction times than congruent trials (657 ± 52 ms). The interaction between target type and cue type was significant, $F(3, 81) = 3.85$, $p = 0.012$, $^2 = 0.13$. Simple effects analysis revealed significant differences between self and friend faces under all cue conditions: no cue, $F(1, 27) = 14.25$, $p = 0.001$; central cue, $F(1, 27) = 34.07$, $p < 0.001$; double cue, $F(1, 27) = 24.65$, $p < 0.001$; spatial cue, $F(1, 27) = 48.18$, $p < 0.001$. No other two-way or three-way interactions were significant (all $ps > 0.1$).

To further compare processing efficiency differences across attention networks for self and friend faces, we calculated efficiency scores for alerting, orienting, and executive control networks according to the ANT operational definitions and conducted paired samples t-tests. Results showed no significant difference in alerting network efficiency, $t(27) = 0.99$, $p > 0.1$ (M_{self} = 45 ± 34 ms, M_{friend} = 38 ± 34 ms). Orienting network efficiency differed significantly, $t(27) = 2.48$, $p = 0.02$, Cohen' s $d = 0.47$ (M_{self} = 64 ± 46 ms, M_{friend} = 48 ± 38 ms). Executive control network efficiency showed no significant difference, $t(27) = 0.77$, $p > 0.1$ (M_{self} = 17 ± 23 ms, M_{friend} = 14 ± 18 ms). These results are depicted in Figure 2 [Figure 2: see original paper].

Experiment 1 demonstrated that when participants were required to ignore flanker stimuli and judge only the centrally presented face, responses to self-faces were significantly faster than to friend faces, consistent with previous research (Tong & Nakayama, 1999; Pannese & Hirsch, 2010; Zhu et al., 2015). More importantly, when examining whether different face types showed differential processing efficiency across the three attention networks, only the orienting network showed a significant difference between self and friend faces, with self-faces demonstrating significantly higher orienting efficiency. No differences emerged in the alerting or executive control networks. This suggests that the attentional advantage for self-faces occurs specifically in the orienting network, likely because the orienting network prioritizes the most important information during massive information input, focusing attention on the spatial location where the target will appear and thereby reducing attentional resource depletion (Mackie et al., 2013). Consequently, self-faces as target stimuli more readily generate attentional orienting effects. However, self-faces showed no advantage in the alerting or executive control networks. We propose that the alerting network primarily serves primary sensory processing input, reducing temporal uncertainty (Hackley & Valle-Inclán, 1999, 2003) but having limited capacity to enhance processing of fine stimuli such as faces. Previous ERP research has also found no significant differences between self and other faces in early face structural encoding, with differences emerging only later between 220–700 ms, indicating that initial face processing involves configuration before feature information processing (Sui, Zhu, & Han, 2006). The absence of self-face advantage in the executive control network may reflect that this network primarily serves task-related processing (Mackie et al., 2013). In the executive control network, participants maintained attentional resources on target identification without interference from other stimuli (flanker faces), consistent with previous findings that when face stimuli appear as distractors outside the attentional focus, self and other faces produce equivalent interference (Devue & Brédart, 2008; Keyes & Dlugokencka, 2014).

Nevertheless, the orienting bias for self-faces observed in Experiment 1 could not exclude familiarity effects, as self-faces are extremely familiar visual stimuli and people process familiar stimuli faster, independent of the unique identity significance of self-faces. Therefore, Experiment 2 adopted the social association learning paradigm developed by Sui, Liu, Wang, and Han (2009), requiring participants to associate themselves and a friend with different neutral geometric shapes before completing the ANT, thereby excluding issues of self-face familiarity and complexity. We expected that newly associated shapes would show similar attention network processing patterns as those observed in Experiment 1.

Experiment 2: Processing Efficiency of Self-Information in the Three Attention Sub-Networks–Self-Associated Shapes as the Response Target

Participants

Thirty undergraduate and graduate students (13 male, 17 female) participated in the experiment. Participants ranged in age from 20 to 33 years (M = 23.73, SD = 2.12), had normal or corrected-to-normal vision, no color blindness, and were right-handed. Participants received monetary compensation after completing the experiment.

Materials

Both the shape-label association learning task and the ANT used white diamond or triangle shapes measuring 1.6° × 1.6° as target stimuli. For congruent flanker trials, flanker stimuli matched the target stimulus (five identical shapes); for incongruent flanker trials, flankers differed from the target (e.g., when the target was a diamond, two triangles flanked each side). Shapes were separated by 0.1°, forming a stimulus array measuring 8.4° × 1.6°. All other materials and equipment were identical to Experiment 1.

Design

The experiment employed a within-subjects design with three factors: target type (self-shape, friend shape, no-social-meaning shape) × cue type (no cue, central cue, double cue, spatial cue) × flanker type (congruent, incongruent). This design examined whether newly associated self-shapes would show attention network processing patterns consistent with those observed for faces.

Procedure

The experiment consisted of two parts: an identity test and a no-social-meaning shape test. The identity test required participants to first complete a shape-identity label (self/friend) association learning task before performing the ANT. The no-social-meaning shape test required participants to complete only the ANT with geometric shapes.

Identity test: Participants first imagined that a diamond and triangle represented themselves and a same-sex friend (participants were asked to think of a specific existing friend; shape-identity mapping was counterbalanced across participants). After imagination, participants performed a keypress task. In each trial, a geometric shape appeared at the center of the screen, with “self” and “friend” options and corresponding response keys (8 and 9) presented below (response key mapping was randomized). Participants judged which identity the shape represented. After responding, the stimulus screen disappeared, followed by a 500 ms feedback screen. This phase consisted of one practice block (8 trials) and one formal block (16 trials), requiring 100% accuracy to proceed. After a brief rest, participants completed the ANT, judging whether the target shape represented themselves or their friend as quickly and accurately as possible. All other procedures were identical to Experiment 1. The total duration was approximately 25 minutes (see Figure 3 [Figure 3: see original paper] for the procedure).

No-social-meaning shape test: Participants judged whether the target shape was a diamond or triangle as quickly and accurately as possible. Duration was approximately 10 minutes.

Because the no-social-meaning shape test and identity test used identical shapes (diamonds and triangles), a two-week interval separated the two parts to avoid memory carryover effects from one test influencing the other. Half of the participants completed the identity test first, followed by the no-social-meaning test two weeks later, while the other half completed the tests in reverse order.

Results

Participants’ reaction times and accuracy rates for shape identity judgments across conditions were calculated (see Table 2). After excluding incorrect responses and trials with reaction times shorter than 200 ms or longer than 1200 ms (accounting for 4.84% of all data), repeated measures ANOVA was conducted on target judgment reaction times and attention network processing efficiency for shapes with different identities.

Table 2 shows reaction times and accuracy rates for processing shapes with different identities. Repeated measures ANOVA revealed a marginally significant main effect of target type, F(2, 58) = 2.99, $p = 0.058$, $^{2} = 0.09$ (M_{self}-shape = 575 ± 56 ms, M_{friend}-shape = 586 ± 56 ms, M_{no}-social-meaning = 602 ± 67 ms). The main effect of cue type was significant, F(3, 87) = 179.33, $p < 0.001$, $^{2} = 0.86$. Post-hoc comparisons showed that spatial cue trials (560 ± 50 ms) were significantly faster than the other three cue types, and double cue (576 ± 52 ms) and central cue (580 ± 51 ms) were both significantly faster than no cue (634 ± 48 ms, all ps < 0.001). The difference between double cue and central cue was not significant, $p > 0.1$. The main effect of flanker type was significant, F(1, 29) = 84.37, $p < 0.001$, $^{2} = 0.74$, with incongruent flanker trials (597 ± 48 ms) showing significantly longer reaction times than congruent trials (577 ± 51 ms). The interaction between target type and cue type was significant, F(6, 174) = 2.63, $p = 0.036$, $^{2} = 0.08$. Simple effects analysis revealed no significant differences among the three shape types under no cue, F(2, 58) = 1.84, $p > 0.1$, central cue, F(2, 58) = 1.18, $p > 0.1$, or double cue conditions, F(2, 58) = 2.69, $p = 0.077$. However, under spatial cue conditions, the difference was significant, F(2, 58) = 5.91, $p = 0.005$, with self-shapes differing significantly from friend shapes ($p = 0.002$) and no-social-meaning shapes ($p = 0.007$), while the latter two did not differ significantly ($p > 0.1$). The interaction between target type and flanker type was not significant, F(2, 58) = 0.36, $p > 0.1$. The interaction between cue type and flanker type was marginally significant, F(3, 87) = 2.28, $p = 0.09$. The three-way interaction was not significant, F(6, 174) = 1.74, $p > 0.1$.

Based on reaction times across the four cue conditions, we calculated processing efficiency for the three attention networks when discriminating self, friend, and no-social-meaning shapes and conducted one-way repeated measures ANOVA for each network. Results showed no significant differences in alerting network efficiency, F(2, 58) = 0.19, $p > 0.1$ (M_{self}-shape = 61 ± 27 ms, M_{friend}-shape = 56 ± 32 ms, M_{no}-social-meaning = 57 ± 40 ms). Orienting network efficiency differed significantly, F(2, 58) = 30.40, $p < 0.001$, $^{2} = 0.51$. Further comparisons revealed that self-shapes differed significantly from both friend shapes and no-social-meaning shapes (both ps < 0.001), while friend and no-social-meaning shapes did not differ significantly, $p > 0.1$ (M_{self}-shape = 37 ± 25 ms, M_{friend}-shape = 13 ± 21 ms, M_{no}-social-meaning = 10 ± 28 ms). Executive control network efficiency showed no significant differences, F(2, 58) = 0.36, $p > 0.1$ (M_{self}-shape = 23 ± 20 ms, M_{friend}-shape = 19 ± 18 ms, M_{no}-social-meaning = 18 ± 25 ms). These results are depicted in Figure 4 [Figure 4: see original paper].

Experiment 2 found that when the task required judging shapes with different identity meanings, the main effect of target type was only marginally significant ($p = 0.058$), suggesting that the processing advantage for newly established self-associated shapes was not yet robust. We propose that although shapes were associated with identity, their visual salience remained lower than that of real faces, confirming the specificity of face processing in the attentional system, consistent with previous research (Federico et al., 2013; Palermo & Rhodes, 2007).

Further examination of processing efficiency across attention networks for different shape types yielded results similar to Experiment 1. In the orienting network, self-shapes showed significantly higher processing efficiency than friend and no-social-meaning shapes, while the latter two did not differ significantly. No significant differences emerged among the three shape types in the alerting or executive control networks. Experiment 2 confirmed that the orienting bias for self-information is not due to visual familiarity but rather to the distinctive meaningfulness of self-information. Notably, friend and no-social-meaning shapes showed no difference in orienting network efficiency. If the orienting network showed a processing bias for all socially meaningful stimuli, we would expect friend shapes to show greater efficiency than no-social-meaning shapes, yet no such difference was observed. This further validates the specificity of self-information: whether highly familiar self-faces or newly associated self-information, the orienting network actively enhances processing efficiency for self-related information.

Based on results from Experiments 1 and 2, we conclude that the processing advantage for self-related information occurs specifically in the orienting network. However, some studies on self-information perceptual processing have failed to find such advantages (Devue, Laloyaux, Feyers, Theeuwes, & Brédart, 2009; Turk et al., 2013). In addition to methodological differences, a key commonality among these studies is that self-information was presented as a non-target stimulus. How does self-information affect attention network operation when it appears as task-irrelevant information? To address this question, Experiment 3 required participants to judge only the color type of the target stimulus while ignoring its facial features (whether it was self or friend). We predicted that when self-faces were task-irrelevant, the orienting network would no longer enhance self-face processing efficiency, and the reaction time advantage for self-faces in the orienting network would disappear.

Experiment 3: Processing Efficiency of Self-Information in the Three Attention Sub-Networks–Self-Face as the Non-Response Target

Participants

Twenty-four undergraduate and graduate students (12 male, 12 female) participated in the experiment. Participants ranged in age from 19 to 33 years (M = 23.83, SD = 2.55), were all right-handed, had normal or corrected-to-normal vision, and no color blindness. Participants completed the experiment in same-sex pairs who had known each other for at least one year and received monetary compensation after completing the experiment.

Materials, Design, and Procedure

The experimental apparatus, materials, design, and procedure were identical to Experiment 1 except for the following modifications. Before the experiment, frontal face photographs of all participants were taken and processed using Adobe Photoshop CS6. Photos were desaturated to grayscale and color-balanced to create red and green face images as stimulus materials. Instructions informed participants to judge only the color of the target stimulus without attending to face type. For congruent flanker trials, flanker faces matched the target face in both color and identity (e.g., five red self-faces or five friend faces); for incongruent flanker trials, flankers differed from the target only in color, not face type (e.g., a red self-face at the center flanked by two green self-faces on each side). Examples of targets and flanker types are shown in Figure 5 [Figure 5: see original paper].

Results

Participants' reaction times and accuracy rates across conditions were calculated (see Table 3). Trials with incorrect responses or reaction times shorter than 200 ms or longer than 1200 ms were excluded (accounting for 6.89% of all data). Data analysis followed the same procedures as Experiment 1.

Results showed no significant main effect of target type, $F(1, 23) = 1.632$, $p > 0.1$ (M_{red} = 652 ± 108 ms, M_{green} = 663 ± 116 ms). The main effect of face type was not significant, $F(1, 23) = 0.94$, $p > 0.1$ (M_{self}-face = 654 ± 110 ms, M_{friend}-face = 659 ± 113 ms). The main effect of cue type was significant, $F(3, 69) = 37.91$, $p < 0.001$, $^{2} = 0.62$. Post-hoc comparisons revealed that spatial cue trials (628 ± 123 ms) were significantly faster than the other three cue types (all $ps < 0.001$), and double cue (648 ± 114 ms) and central cue trials (653 ± 110 ms) were significantly faster than no cue trials (698 ± 101 ms, $ps < 0.05$). The difference between double cue and central cue was not significant, $p > 0.1$. The main effect of flanker type was significant, $F(1, 23) = 20.00$, $p < 0.001$, $^{2} = 0.47$, with incongruent flanker trials (669 ± 109 ms) showing significantly longer reaction times than congruent trials (644 ± 114 ms). No two-way or three-way interactions were significant (all $ps > 0.1$).

Further paired samples t-tests on attention network processing efficiency differences between self-faces and friend faces when faces were task-irrelevant (using the same method as Experiment 1) showed no significant differences in alerting network efficiency, $t(23) = 0.34$, $p > 0.1$ (M_{self} = 52 ± 40 ms, M_{friend} = 49 ± 42 ms); orienting network efficiency, $t(23) = 0.80$, $p > 0.1$ (M_{self} = 21 ± 49 ms, M_{friend} = 29 ± 42 ms); or executive control network efficiency, $t(23) = 0.40$, $p > 0.1$ (M_{self} = 23 ± 31 ms, M_{friend} = 26 ± 33 ms). These results are shown in Figure 6 [Figure 6: see original paper].

Experiment 3 found that when the task required judging target stimulus color, the main effect of target type was not significant, indicating that color type did not affect identification speed. When examining processing efficiency across the three attention networks for different face types, the orienting advantage for self-faces disappeared. We propose that when facial features are task-irrelevant and participants are not required to make judgments about face identity, the orienting network no longer prioritizes processing of task-irrelevant facial features. The primary function of the orienting network is to direct attention to stimuli that will be selected or attended, and its processing priority adjusts according to task goals (Corbetta & Shulman, 2002; Farrant & Uddin, 2015). Research indicates that when stimuli appear, the ventral attention network activates prominently; if stimuli are task-irrelevant, the ventral attention network acts as a "circuit breaker," sending signals that inhibit dorsal attention network activity, causing attention to be reoriented (Shulman, D' Avossa, Tansy, & Corbetta, 2002; Corbetta, Patel, & Shulman, 2008). Perceptual features of stimuli only influence processing when relevant to the current task; therefore, when stimulus features are task-irrelevant, they fail to activate brain regions associated with spatial attention even if they are salient (Indovina & Macaluso, 2007; Jannati, Gaspar, & McDonald, 2013).

General Discussion

This study examined processing efficiency differences between self and other information across three attention sub-networks (alerting, orienting, and executive control) through three experiments. In Experiment 1, we found that when face type served as the target, self-faces showed a processing advantage, with a significant main effect of target type—participants responded significantly faster to self-face targets than to other-face targets. Further analysis of self-face advantages across attention networks revealed that self-faces showed processing advantages specifically in the orienting network, with no efficiency differences between self and other faces in the other two networks. Experiment 2 replicated these findings using a social association learning paradigm. Although the main effect of target type was only marginally significant (possibly because self-associated shapes were less visually salient than real faces), further examination of processing efficiency across attention networks revealed that in the orienting network, self-shapes showed significantly higher processing efficiency than friend and no-social-meaning shapes, with results similar to Experiment 1. This provides evidence that face familiarity and complexity are not the reasons for self-information advantages in the orienting network. Experiment 3 changed the target judgment to color discrimination (with facial features as task-irrelevant information), and results showed that the orienting advantage for self-faces disappeared. Across all three experiments, we conclude that the attentional advantage for self-related information occurs specifically in the orienting network, and that self-information influences attention through its effects on the orienting network.

To understand why self-information shows greater processing advantages in the orienting network, it is necessary to consider the characteristics of the orienting network itself. In the attention system, orienting refers to the ability to select specific information from massive environmental input (Corbetta & Shulman, 2002; Fan et al., 2005), comprising a complex cognitive process involving three stages: attentional disengaging, shifting, and engaging. Specifically, attention must be disengaged from its current focus, shifted, reoriented, and then engaged with a new target, making orienting a process of directing attention to stimuli that will be selected or attended. Neuroimaging research on attention networks indicates that the orienting network includes both dorsal and ventral attention networks: the dorsal attention network is associated with endogenous attention, showing enhanced activity after cue presentation and representing the primary brain regions activated in top-down attentional control, mainly distributed in bilateral IPS, superior parietal lobule (SPL), and FEF; the ventral attention network is associated with exogenous attention, driven by external environmental stimuli to guide attention to salient objects, mainly distributed in the right ventral frontal cortex (VFC), right temporal-parietal junction (TPJ), portions of medial frontal cortex (MFC), and IFG (Uddin, 2015; Farrant & Uddin, 2015; Tang et al., 2016). Meanwhile, some studies have found that when self-information serves as a cue, individuals can more effectively allocate attention to the spatial location indicated by self-information, establishing a foundation for self-information to influence attentional orienting. Yamada, Kawabe, and Miura (2012) found that one' s own name could influence attentional localization, causing a 1.61 arcmin localization error biased toward the name, demonstrating more stable and positive processing of self-information. Liu, Wang, Sui, and Zhang (2012) found that self-faces as endogenous cues could more effectively trigger attention shifts to the cued location. In the present study, using the ANT to separate the three sub-functions of attention, we found that participants showed processing advantages in the orienting network when judging self-information. This may occur because the ventral attention network is driven by external stimuli, with self-information as a salient stimulus capturing attention bottom-up, while participants' prior knowledge that the task required identity judgments created top-down readiness for self-information processing. After cue presentation, the dorsal attention network showed enhanced activity, actively directing attention to spatial locations relevant to the current task goal (Tang et al., 2016). Therefore, when identity information served as the target, self-information more easily dominated orienting network processing, resulting in attentional advantages in the orienting network. However, when identity information was not the target, the dorsal attention network suppressed the attention-capturing effect of self-information according to task demands, inhibiting inappropriate responses to task-irrelevant stimuli (Garza, Strom, Wright, Roberts, & Reed, 2013; Keyes & Dlugokencka, 2014). Thus, we speculate that the disappearance of orienting bias for self-faces in Experiment 3 reflects the task-priority processing characteristic of the orienting network (Crottaz-Herbette & Menon, 2006; Rothbart & Posner, 2015), which serves target task processing.

Conversely, this study found no processing advantages for self-information in the alerting or executive control networks. We propose the following explanations: Sui et al. (2006) found no differences between self and other faces in early face structural encoding (ERP components VPP, N170), with differences emerging only later between 220–700 ms, suggesting that self-face advantages occur after face configuration. Previous research has found that the ERP component associated with the alerting network is N1, whose enhancement reflects enhanced input of relevant information in primary sensory processing. The alerting network primarily serves primary sensory information input and has limited capacity to further enhance processing of fine stimuli such as self-faces (Neuhaus et al., 2010; Federico et al., 2013). Therefore, this study did not find self-face advantages in the alerting network. Although both alerting and orienting networks provide anticipatory states for upcoming stimuli, the alerting network' s enhancement of primary sensory processing does not involve processing of stimulus attributes and meaning, whereas the orienting network provides temporal and spatial preparation for self-information processing, enabling us to detect stable processing advantages for self-information in the orienting network. Additionally, the executive control network in this study showed equivalent efficiency for both stimulus types (self and friend), primarily because executive control functions are most crucial for completing goal-directed behavior and inhibiting prepotent response tendencies (Haykin, Fatemi, Setoodeh, & Xue, 2012), resolving conflicts between target stimulus attributes and flanker stimulus attributes (Engle & Kane, 2003). Therefore, the executive control network represents an autonomous control process, a so-called “cool” executive function (Li & Cai, 2013), capable of effectively inhibiting self-information when it serves as a flanker distractor.

It is worth noting that this study replaced arrows in the ANT with real faces. The original ANT combines a cued target task with a flanker task, with both cue settings and target stimuli related to spatial location. Previous research has shown that stimulus directional attributes affect attention networks in the ANT (Spagna et al., 2014), though whether they influence attentional characteristics of socially meaningful stimuli remains unclear. Many studies have used modified flanker tasks (replacing arrows with emotional faces or letters) to examine attentional characteristics of socially meaningful information (Mueller & Kuchinke, 2016; Kim, Kang, Cho, & Lee, 2017). The present study also explored how self-other attribute differences affect attention based on socially meaningful stimuli. While the reduction of directional attributes affected self and other stimuli equally, whether this influence contributed to the absence of differences in the alerting and executive control networks in this study requires further investigation.

In conclusion, this study further clarifies that the processing advantage for self-related information exists primarily in the orienting network of attention and validates this conclusion by manipulating task relevance, providing a clearer and more explicit explanation for the mechanisms underlying self-information attentional advantages. (1) Among the three attention sub-networks, the orienting network plays a crucial role in self-processing advantages, while alerting and executive control networks show no special processing bias. (2) The task-priority characteristic of the orienting network influences the emergence and disappearance of self-information attentional advantages.

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