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Attention network test — The impact of social information on executive control, alerting and orienting

Francesca Federico [a], Andrea Marotta [b], Tiziana Adriani [a], Lisa Maccari [b], Maria Casagrande [b,*]

[a] Dipartimento di Psicologia dei Processi di Sviluppo e Socializzazione — "Sapienza" Università di Roma, Italy
[b] Dipartimento di Psicologia — "Sapienza" Università di Roma, Italy

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A B S T R A C T

According to the attention network approach, attention is best understood in terms of three functionally and neuroanatomically distinct networks — alerting, orienting, and executive attention. An important question is whether social information influences the efficiency of these networks. Using the same structure as the Attentional Network Test (ANT), we developed a variant of this test to examine attentional effects in response to stimuli with and without social-cognitive content. Fish, drawings or photographs of faces looking to the left or right were used as target stimuli. Results collected from twenty-four university students showed that photographs of faces positively affected attentional orienting and executive control, whereas reduced the efficiency of alerting, as compared to both face drawings and fish. These results support the status of human faces as a special class of visual stimuli for the human attentional systems.

1. Introduction

Faces are the most important source of social information (including identity of the person, expression, gaze direction, age, and gender), often crucial in establishing social interactions (Shults, 2005). Among objects, the uniqueness of faces for the human attentional system has been demonstrated in a growing number of studies by using different methods (Birmingham & Kingstone, 2009; Kanwisher, 2000). Faces are more likely to capture attention than other objects (Bindemann, Burton, Langton, Schweinberger, & Doherty, 2007; Langton, Law, Burton, & Schweinberger, 2008; Ro, Friggel, & Lavie, 2007) and they cannot be ignored even under conditions of high perceptual load (Lavie, Ro, & Russel, 2003). In addition, merely seeing a face with an averted gaze can shift one's own attention in the corresponding direction of the seen gaze (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Marotta, Lupiáñez, & Casagrande, 2012; Marotta, Lupiáñez, Martella, & Casagrande, 2012). These gaze-cueing effects occur after milliseconds of the appearance of a face (e.g., 14 ms, Hietanen & Leppanen, 2003) and even when gaze following is disadvantageous (e.g., Driver et al., 1999; Friesen, Ristic, & Kingstone, 2004). Such findings imply that faces and eye-gaze direction are difficult to ignore. Obligatory gaze perception is consistent with the central role of gaze signals in social interaction and communication, as when gaze allows to establish joint attention (Moore & Dunham, 1995) or to infer the intentions or mental states of others (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995). However, in everyday life, people are often faced with complex social array containing conflicting gaze information from multiple faces. Consequently, the ability to control the extent that gaze information influences cognition is crucial for successful decision making and social interactions. A key question is how people control the processing of contrasting social relevant information, such as gaze direction from multiple faces.

In order to examine the executive control of social information, such as eye-gaze direction, in the current study we developed a variant of the Attention Network Test (ANT) (Fan, McCandliss, Sommer, Raz, & Posner, 2002), an experimental measure of the three attention networks: alerting, orienting and executive control (Posner & Petersen, 1990). The alerting network is concerned with an individual's ability to achieve and maintain a state of increased sensitivity to incoming information, the orienting network manages the ability to select and focus on the to-be-attended stimulus, and the executive control network manages the ability to control our own behavior to achieve intended goals and resolve conflict among alternative responses. Of particular relevance to the present study, in the ANT the executive control has been generally measured by a flanker task in which participants are required to identify the direction of a central arrow target flanked by congruent or incongruent stimuli (arrows in the same or in the opposite direction as the target, respectively). Participants are typically faster when the target arrow and the flanking arrows are congruent, than when they are incongruent

* Corresponding author. tel. + 0396 49917787
E-mail address: maria.casagrande@uniroma1.it (M. Casagrande).

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(i.e. flanker interference effect). Different types of stimuli have been used in different versions of this paradigm, such as fish (Rueda et al., 2004) and cars (Roca et al., 2012). However, to our knowledge eye-gaze has never been used as target stimuli in the ANT and only one study (Dichter & Belger, 2007) has directly compared cognitive control in response to social and no-social stimuli in a flanker task (eye-gaze and arrow stimuli, respectively). Of interest for the present study, Dichter and Belger (2007) observed that only arrow stimuli, but not eye-gaze, produced interference effect in typically developing individuals. This suggests that people are engaged in more effective controlled processing when social relevant stimuli, such as eye-gaze direction, are used as compared to when no-social stimuli are employed.

In the present study, we examined cognitive control in response to stimuli with and without social-cognitive content by means of the ANT. We also assessed whether social stimuli can influence the efficiency of the other two attentional networks, alerting and orienting. In particular, we developed two social variant of the ANT, in which drawings or photographs of faces looking to the left or right were used as target stimuli. Moreover, the version of ANT developed by Rueda et al. (2004), with fish as stimuli was used to assess no-social attentional processes.[1]

We directly tested the following predictions: people will be engaged in more effective controlled processing when social relevant stimuli (drawings and photographs of faces) will be used as target compared to when no-social stimuli (fish) will be used. We also expect that social stimuli will facilitate attentional orienting as compared to no-social stimuli, in line with the previous findings showing that faces are more effective in attracting and holding attention than other object (Bayliss & Tipper, 2005; Bindemann et al., 2007). However, we make no prediction about the differences between social and no-social stimuli in alerting.

2. Method

2.1. Participants

Twenty university students (13 females and 7 males; mean age 26.1 ± 2.4 years) signed an informed consent before participating as volunteers in the study. The local ethical committee approved the study. All participants had normal or corrected-to-normal vision, and were unaware of the purpose of the experiment.

2.2. Apparatus

Stimuli were presented on a 12-in. color VGA monitor. An IBM-compatible PC running E-Prime software controlled the presentation of the stimuli, timing operations, and data collection. Responses were gathered with a standard computer mouse.

2.3. Stimuli

Stimuli and trial sequences are illustrated in the Fig. 1.

Each participant completed three different versions of the ANT that differed only in the types of stimuli that appeared. All participants completed a version that presented colored fish as target and flanker stimuli, just as described in Rueda et al. (2004). All participants also completed two new versions of the task that presented drawings or photographs of faces instead of fish. The target array consisted of a central target stimulus and four flanker stimuli. Each stimulus subtended 1.6° (degree of visual angle) and the contours of adjacent stimulus were separated by 0.21°. The five stimuli subtended a total of 8.84°. The target was presented either about 1° above or below fixation. Each target was preceded by one of four cue conditions: a center cue, a double cue, a spatial cue, or no cue. Each cue stimulus subtended 1.5° of visual angle. The auditory and visual feedback was an animation showing the target fish blowing bubbles (or a red smile on the face) and exclaiming “Woohoo!” when a correct response was given. Incorrect responses were followed by a single tone and no animation.

2.4. Procedure

The experimental session consisted of three tasks: the fish version (ANT.Fish), the face drawings version (ANT.Face drawings) and the face photographs version (ANT.Face photographs). The order of each task was randomized across participants. Each of the tasks consisted of a practice block with 24 trials and two experimental blocks of 48 trials each. Participants could take breaks at the end of the practice block and between tasks.

The instructions were the same for all the versions of the task. Participants were told that a drawing or a photograph of a face (or a fish) would appear on the screen and that the purpose of the task was to press the button on the mouse that matched the direction the face was looking (or fish was directed). Each target was preceded by a cue stimulus that either alerts or orients participants to the upcoming target. There were four cue types: no-cue (neither alerting nor orienting cue was presented), double-cue (a double-asterisks cue appearing simultaneously above and below fixation; alerting), spatial cue (a single asterisk presented in the position of the upcoming target; orienting), or central cue (an asterisk presented at the location of the fixation cross). Immediately after the cue, the target appeared and was flanked by one of the two flanker types: congruent (flankers in the same direction as the target) and incongruent (flankers in the opposite direction as the target). Participants were instructed to pay attention to the face (or fish) in the middle and press whichever button matched the direction gaze face (or fish). Participants were instructed to maintain fixation on the cross in the center of the screen throughout the task and to respond as quickly and accurately as possible. Each trial began with a fixation period of random variable duration of between 400 and 1600 ms. Subsequently, on some trials a cue was presented for 150 ms. A brief fixation period of 450 ms appeared after the disappearance of the cue, followed by the simultaneous appearance of the target and flanker. This display remained on the screen until a response was detected, to a maximum of 1700 ms. After responding, the participant received auditory and visual feedback from the computer. For correct responses the participant was presented with a recording of “Woohoo!” exclamation. Incorrect responses were followed by a single tone. Measures of the efficiency of the three attentional networks were obtained via simple subtractions of reaction times between conditions. The so-called “conflict effect” is calculated by subtracting the mean reaction times (RTs) of the congruent flanking conditions from the mean RTs of incongruent flanking conditions. The two conditions differ only in the information given by the flankers. When the images are congruent, they provide a facilitating effect on the discrimination of the target stimulus, whereas incongruent flankers distract participants. Visual cues are used to separately assess the alerting (improved performance following a double cue) and orienting (an additional benefit when the cue correctly indicates the target location, i.e., a spatial vs. center-cue) attentional functions. The orienting effect is calculated by subtracting the mean RTs of the spatial-cue conditions from the mean RTs of the center-cue conditions. Both center and spatial cues alert the participant to the forthcoming appearance of the target, but only the spatial-cue provides spatial information, which allows participants to orient their attention to the appropriate spatial location. Therefore, the RTs' difference between spatial and center cues provides a measure of orienting attention. In the no-cue or double-cue conditions, attention tends to be diffused across the two potential target

[1] In this study we chose to use the ANT with fish as stimuli (Rueda et al., 2004) rather than original ANT with arrows (Fan et al., 2002) in order to ensure that we could match social stimuli (drawings/photographs of faces) and no social stimuli (colorful fishes) in relation to some of their saliency features.