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Review Paper

Human Face and Attention: a review

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ABSTRACT

The human face is a very important visual stimulus in the human experiential world. It is a powerful social stimulus and is also responsible for drawing inferences about individuals we come across in our day to day lives. Information can be gained from both its static form and also its dynamic form the human face. This review aims to explore various studies involving face perception with emphasis on how it influences cognitive processes along with special emphasis on attention and its underlying mechanisms. Existing literature indicates that facial stimuli does play a strong role in influencing attentional processes including sustained, spatial, covert and overt attention.

Keywords: *Human Face, Facial Attractiveness, Spatial Attention, Overt Attention, Covert Attention, Cognitive Processes, Attentional Processes*

Throughout evolution of mankind, the human cognitive system has consistently adapted itself to detect and pursue attractive faces (Maner *et al.* 2007)[1]. Attractive faces can be clearly distinguished from unattractive ones as early as 13 ms from viewing (Olson and Marshuetz 2005)[2]. Faces which are considered to be attractive also have a higher response in event related potentials than unattractive faces (Van Hooff *et al.* 2011)[3]. Whenever an attractive face is presented in a participant's visual field in comparison to a target letter, there exists likelihood that his or her attention would be transiently oriented towards the location of the attractive face (Sui and Liu 2009)[4]. Li, Oksama and Hyona investigated whether facial attractiveness has any effect on sustained attention using low level features of luminance, contrast and colour saturation and high-level features like symmetry, averageness, youth and physical beauty based on the process of attentional tracking (Kniffin and Wilson 2004[5]; Langlois and Roggman 1990[6]; Little *et al.* 2011[7]; Russell 2003[8]; Thornhill and Gangstead 1999)[9]. High level properties attractive target faces were automatically processed facilitating sustained attention on attractive targets. People with attractive faces have also been found to receive more favourable gestures, have better chances for hiring and promotion (Dipboye *et al.* 1977[10]; Landy and Sigall 1974[11]) and are often considered to be more smarter, highly extraverted and in better possession of social skills (Dion *et al.* 1972[12]) and often considered by viewers to be more effective in classroom instruction (Amabady and Rosenthal 1993 [13]; Hamermesh and Parker 2003 [14]).

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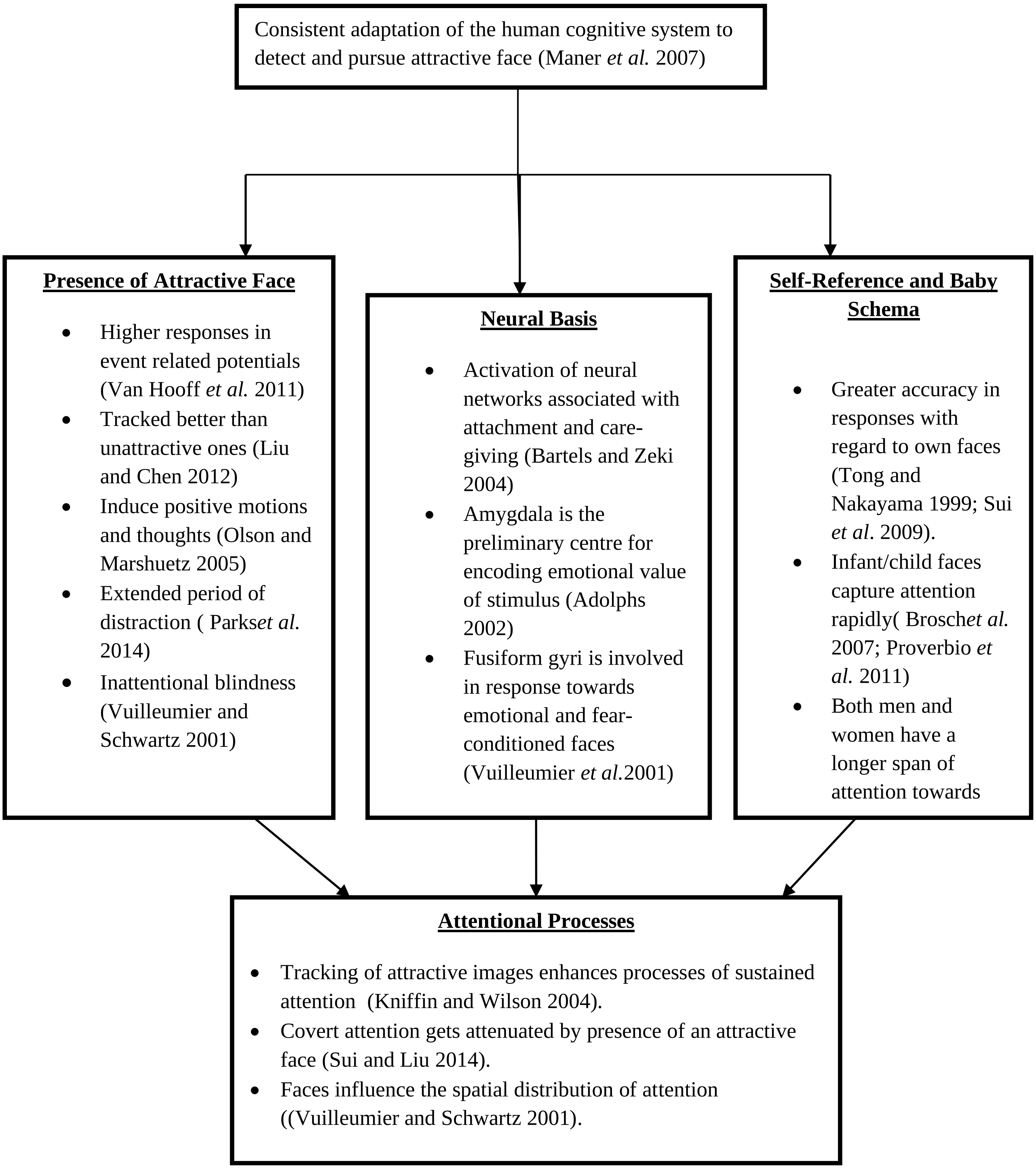
Figure 1: Schematic representation of the basic findings of the review



Liu and Chen indicated that the locations of attractive targets were actually tracked in a better manner than in comparison to the lesser attractive targets (Liu and Chen 2012[15]). This particular study highlighted the fact that during attentional tracking of multiple moving faces of different attractiveness, both high-level and low-level properties of the target faces can actually be automatically processed but in case of distracters only low-level properties are processed. Attractive faces were also tracked better than unattractive faces with or without distinctive low-level visual features (Li *et al.* 2016)[16] . Attractive faces have also been found to induce positive emotions and thoughts as such (Olson and Marshuetz 2005)[17]. All these findings do suggest that faces do serve to be an important source of inferential social information and communication and it may also be possible that they act as strong mediators for influencing our cognitive processes.

Human faces are able to capture attention more easily than other objects (Ro *et al.* 2001)[18]. Generally, visual stimuli with both social and emotional content tend to attract attention. Typically, the human visual system confronted with many more objects than it can simultaneously process. Neural mechanisms for attention involve a complex network of brain areas which are required to choose relevant sensory information for purpose of conscious perception and action (Mesulam 1981[19]; Heilman *et al*. 1993[20]).

Research investigations in people with neural deficits has shown that faces have an inclination to capture attention more easily, especially if their expressions indicate happiness, sadness or anger (Hansen and Hansen 1988[21]; White 1995[22]). A study was conducted by Vuilleumier and Schwartz in patients with unilateral inattention owing to left spatial neglect. Experimental stimuli comprised of black outline drawings of schematic faces with happy, angry or neutral expression along with a meaningless oval shape. Results indicated that facial features along with emotional expressions could be detected despite lying on the unattented side. This suggests their influence on the spatial distribution of attention. Faces could be discriminated from various other stimuli despite the presence of contra-lesional inattention. This has also been reported in studies of inattentional blindness (Mack and Rock 1998[23]). Thus, it may be inferred that faces do have the ability to attract attention despite deficits in attentional processes.

A significant and critical function of attention is to direct our perception towards the direction of salient stimuli resulting in fast and accurate response to these stimuli. These 'salient' features of stimuli are mostly characterized by basic physical attributes like high luminance. However, a strong set of stimuli which has been found to strongly bias attention is human face. Humans also have an attentional bias towards stimuli which are characterized by an approaching threat. In case of tasks based on visual search paradigm, participants were found to detect angry faces more readily than happy faces (Eastwood *et al.* 2001[24]; Hansen and Hansen 1988[21]). In order to investigate the process of distraction and the underlying bias of attention, a novel discrimination task was used by Parks and colleagues. They found that an extended period of distraction was observed whenever the stimuli was a face. This holding of attention by faces would occur regardless of emotional expression (Parks *et al.* 2014)[25].

The self-reference effects

Additionally, it is believed that facial images actually attract attention and also facilitate subsequent processing at the locations where they occur (Axelrod *et al.* 2015)[26]. People also tend to make faster and greater accurate responses with regard to their own faces than in comparison to the faces of familiar others (Sui *et al.*2009[27] ; Tong and Nakayama 1999[28]). Essentially in this phenomena, the self-advantage effect tends to play a role. (Sui and Han 2007[29]). To further investigate this domain, Liu and colleagues investigated the effects of non-informative dynamic facial cues with an extension of the study using event related potentials (ERP). Results confirmed that dynamic facial cues were faster in eliciting attention-related responses in case of self-faces than in comparison to the faces of other people. The ERP results also indicated that self-facial cues could also elicit greater amplitudes over the left central-parietal region with a smaller amplitude in the right frontal-central-parietal cortex (Liu *et al.* 2016)[16]. There exists an enhanced sensory processing towards self-faces which subsequently reduce the existing probability of the relationship between the cue and its subsequent target (Sutton *et al.*1965)[30].

There have also being studies to assess whether facial attractiveness can also be detected even when it is outside the sphere of foveal vision. A measure for this would be to assess the effect of facial attractiveness on covert attention. Sui & Liu in 2012 aimed to investigate this domain using a spatial cuing task and in case of attractive faces, the task performance was found to get lengthened but in case of unattractive faces would no significant effect was seen (Sui and Liu 2014)[31]. This allocation of covert attention by subjects was actually more attenuated by an attractive face rather than an unattractive face even though if the face was not relevant to the task (Olson and Marshuetz 2005 [17];Locher*et al.* 1993)[32].

Attraction towards infant faces

Specific features exist in infant faces which were termed as "kindchenschema' or 'baby schema' by Konrad Lorenz (Lorenz 1943)[33]. Faces of young children and infants are considered to possess cross-cultural emotive stimuli as a result of which adults find them to be cute and very likeable and they have also been found to evoke feelings of protectiveness and care (Brosch *et al.* 2007[34]; Luo *et al.* 2011[35]; Proverbio *et al.* 2011[36,37]; Borgi *et al.* 2014)[38]. This could be responsible for the increased attention towards faces of infants.

Neural basis of attraction towards infant faces

Viewing infant and child faces has been found to have significant positive effects in adults across various cultures especially with regard to capturing attention rapidly and automatically (Brosch *et al.* 2007,[34]; Proverbio *et al.* 2011)[37], in terms of evoking stimuli (Schleidt *et al.* 1980)[39], fostering protective reactions (Alley 1983)[40], feelings of closeness and exaggeration of greeting responses (Eibl-Eibesfeldt 1989)[41].Faces of infants and young children have also been found to enhance attention owing to stronger activation of parietal regions of the brain which involve both processes of bottom up and top down processing for orientation of attention (Shomstein 2012)[42] which involves the intraparietal sulcus (Leibenluft *et al.* 2004)[43], precuncus (Leibenluft *et al.* 2004[43]; Glocker *et al.* 2009[44]) along with the posterior cingulated cortex (Leibenluft *et al.* 2004)[43]. A greater intensity of activation of parietal regions helps in allocating a greater amount of automatic and attentional resources to faces which have baby schema features which further leads to the development of attentional bias towards faces of infants (Brosch *et al.* 2007[34]; Glocker *et al.* 2009[44]; Caria *et al.* 2012)[45]. There also exists a stronger activation response against neutral expressions in faces of unfamiliar infants in the central-frontal and occipital-lateral sites as reported by an evoked-related potential study (Weisman *et al.* 2012)[46].

Characteristics of the Baby Schema Response

Enhanced attention in presence of willingness to care, increased positive affect, engaging in protective behaviour and decreased aggression are fundamental characteristics of the baby schema response also known as the cute response (Lorenz 1943[33]; Alley 1983[40]; Brosch *et al.* 2007[34], Glocker *et al.* 2009[44]; Sherman *et al.* 2009[47]; Nittono *et al.* 2012[48]). Cues from the face also aid in engaging and enhancing nurturance from the caregiver. Focussing attention towards infant faces also enhances the probability that the basic needs for dependent infants will be met (Bard 1994)[49]. A reason for this allocation of attention maybe attributed to the fact that faces act as a source of social information (Ro *et al.* 2001[50]; Ohman *et al.* 2001[50]; Vuilleumier 2000)[51]. Previous studies have indicated that own–age faces appear to be more distracting then faces of other ages (Ebner and Johnson, 2010)[52].

Faces of infants tend to get greater priority in terms of attention by adults (Brosch *et al.* 2007)[34]. Attentional processes have also been found to have an association with quality of maternal relationship and for women who display a greater bias towards infants at their time of distress have been found to have better mother-infant relationships even at 3-6 months of postpartum (Pearson *et al.* 2011)[53].

Infant facial cues also are processed differently and viewing one's own child further leads to activation of neural networks which involve regions for processing emotions and rewards which leads to enhanced maternal attachment and care-giving activities (Strathearn *et al.* 2009[54]; Bartels and Zeki, 2004)[55]. A study conducted by Thompson-Booth and colleagues involving adult and infant faces indicated that presence of infant faces had a tendency to slow down decision making because of their inherent characteristics facilitating greater attention towards them (Thompson-Booth *et al.* 2014)[56]. This has earlier being predicted by the appraisal theories of emotions which highlights the fact that significant stimuli are actually tend to demand a higher allocation of attentional and processing resources (Sander *et al.* 2005)[57].

Young women have been found to be more responsive towards infant faces with better abilities and greater sensitivity in detecting minor gradations and differences in cuteness in infant faces in comparison to men (Sprengelmeyer *et al.*2009)[58]. Often these stimuli are characterized by three components which includes liking, wanting and learning which can also be characterized under separate neural mechanisms (Berridge and Kringelbach 2008[59]; Winkielman *et al.*2005)[60]. This component of infantile attraction has also been investigated in terms of general responsiveness towards infants involving a sample of participants with limited experience of caring about young infants. Both men and women were found to were found to have equal and positive appraisal towards 'cute' unfamiliar infants with emphasis on longer time span of attention towards cute infants than 'less cute' infants (Parsons *et al.* 2011)[61]. 'Cute' infants are considered to be more friendly, cheerful, likeable (Ritter *et al.* 1991[62]; Maier *et al.* 1984[63]; Karraker and Stern 1990[64]; Casey and Ritter 1996[65]) and more adoptable (Volk and Quinsey 2002)[66].

There exists information which indicates that there exist deficiencies in terms of processing of infants from other races in comparison to own race infants. Generally, people tend to be better in discrimination, recognition and detection of changes in infants of their own race rather than from other races (Malpass and Kravitz 1969[67]; Meissner and Brigham 2001;[68] Humphreys *et al.* 2005)[69]. To investigate the reason underlying this, Hodsoll and colleagues conducted a study using a standard probe detection task in order to understand this differential spatial allocation of attention (Brosch *et al.* 2007[34]; Lipp and Derakshan 2005)[70]. Two facial stimuli of different age categories were presented simultaneously on the computer, wherein half of the face pairs were South Asian and half were White. Both South Asian and White participants were made to view face pairs and had to report the orientation of a probe shape which would appear at either location occupied by either the infant face or the adult face. Reaction times appeared to be faster for probes which appeared in the location of infant faces only if they matched the race of the participant (Hodsoll *et al.* 2010)[71]. This may have resulted because the detection of changes in racial cues leads to quicker processing as such (Valentine, 1991)[72].

Effects of Attention on the Human Brain

There exists an overarching control system behind stimuli selection and response which is monitored by the faculty of attention. Attentional processes are involved in the earliest stages of response itself and are considered to play a very crucial and significant role towards efficiency and survivability. The relevance and importance of incoming stimuli is dependent upon the emotional content of stimuli and this emotional content of stimuli is capable of modifying and also altering the direction of attention towards presented stimulus. In general, it is the amygdale and its connectivity which helps in rapid registration of the emotional value of incoming stimuli as it is involved in reception of input from low-level sensory cortices and from other sub-cortical sites (Adolphs 2002)[73]. Therefore, the amygdala acts as the preliminary centre for encoding emotional value of stimulus.

Fear-related stimulus is processed pre-attentively (Ohman *et al.* 2001)[50]. The fusiform gyri situated in the temporal lobe would actually be activated differentially depending on whether facial stimuli would appear at attended or unattended locations. However, the amygdala was not found to be affected by attentional manipulations. Thus, emotional encoding by amygdale is independent of the direction of spatial attention (Vuilleumier *et al.* 2001)[74]. Studies based on event-related potentials (ERPs) have indicated that emotional stimuli can capture attention as early as 105 ms after onset of stimulus. In particular, negative stimuli would enhance P1 at 105ms after stimulus onset and later at P2 at 180ms whereas positive stimuli would capture attention at 180 ms and retain so till 240 ms (Carretie *et al.*2004)[75].

There exists two pathways in which emotions tend to influence attention, one being a direct one wherein the amygdala feeds to the sensory cortical sites which leads to enhancement of responses in the 'bottom-up' manner and the other involves an indirect pathway which involves the interaction between cognitive and emotion-sensitive frontal and cortical areas with the cognitive regions focussing more on the templates of the task being performed and the emotion-sensitive regions being more involved in assessing the emotional salience of incoming stimuli. When subjects are exposed to emotionally valenced images, increased activity has been reported in cortical visual areas (Lane *et al.* 1999;[77] Lane *et al.*1997;[76] Paradiso *et al.* 1999[78]; Simpson *et al.* 2000)[79]. Other associative cortices like the fusiform gyri has also been found to be involved in response towards emotional faces (Vuilleumier *et al.* 2001)[74] or towards fear-conditioned faces (Armony and Dolan 2002 [80]; Morris *et al.* 2001[81]). The ventromedial region of the frontal lobes (VMPFC) has also been found process emotional content of stimuli because of its mutual connections with the amygdala and its ability to suppress or enhance emotional processing due to prefrontal determined aspects (Barbas 2000)[82]. This region may also be considered to be the connecting bridge which helps in conveying information from other subcortical limbic regions like amygdala to the higher cortical and executive centres of Prefrontal cortex.

The amygdala is thus implicated for faster valuation of stimuli and is also able to do so because of its association with anterior and posterior cortical sites. Amygdala is able to bias attention by added activation especially for stimuli associated with negative valence. The orbito-frontal cortex is also responsible for interaction with the dorsal prefrontal cortex sites for endogenous attention.

Attention and Emotion

It is not just the structural configuration of faces but also the emotional value of these faces which are interpreted by pre-attentive visual analysis and actually monitor the allocation of spatial attention (Vuilleumier and Schwatrz, 2001)[83]. Presentation of emotional faces under low levels of awareness by masking leads to activation of the amygdala (Whalen *et al.* 1998[84]; Morris *et al.* 1999) [85], and leads to production of papillary (Tamietto *et al.* 2009)[86] and skin conductance responses (Ohman *et al.* 2001)[87]. The viewing of faces with emotional expressions affects the emotion circuits despite the fact that they are not directly attended to. In case of monkeys, it has been found that the effect of emotional faces as distracters was relevant especially whenever the expression was threatening. Emotional distracters did play a role in attracting attention away from other tasks (Landman *et al.* 2014)[88].

Role of emotional stimuli

Stimuli characterized by emotional significance also get processed even when they are outside the focus of attention or in the absence of awareness. Basic psychophysical studies investigating this domain have indicated that fast involuntary responses towards emotional stimuli tend to occur when they are associated with potential threats like fearful expressions of faces or aversive images (Globisch *et al.* 1999 [89]; Lang *et al.* 1998 [90]; Ohman *et al.* 1995 [91]; Wells and Mathews 1994)[92]. In studies related to patients with spatial neglect, emotional stimuli tend to capture attention more readily than in case of neutral stimuli (Vuilleumier and Schwartz 2001)[83]. It has also been reported that threat-laden stimuli had higher probability of detection when they were presented in the otherwise 'weaker' left field of patients with chronic unilateral left neglect in comparison to stimuli with happy or angry expressions (Vuilleumier and Schwartz 2001)[83].

Whenever both emotional and non-emotional stimuli are presented simultaneously, the emotionally meaningful stimuli tend to capture initial overt orientation which further leads to increased early engagement of attention measured in terms of gaze direction and duration (Calvo and Lang 2004)[93]. Essentially emotional picture processing involves certain mechanisms, either in case of schematic faces or real faces (Fox *et al.* 2000 [94]; Mogg and Bradley 1999 [95]; Ohman *et al.* 2001)[91], in case of phobic stimuli including spiders or blood (Hermans *et al.* 1999 [92]; Ohman et al. 2001)[91] or unpleasant stimuli like images of accidents, assaults and pleasant stimuli like erotic pictures, adventure scenes (Bradley *et al.* 1996;[96] Lang *et al.* 1993)[97]. A major part of the investigations in this area has been carried out based on investigation of basic attentional processes.

Based on a visual search task paradigm, it was found that discrepancy in schematic angry faces were detected much faster than friendlier or sad faces (Fox *et al.* 2000[94], Ohman*et al.* 2001[91]). The free viewing time paradigm suggested that viewers have the tendency to fixate more on unpleasant stimuli than in comparison to neutral stimuli (Christianson *et al.* 1991[98]). Functional imaging techniques in this domain has also indicated that large positive slow wave was responsible for enhanced activation in the occipital cortex after presentation of highly pleasant and unpleasant stimuli (Bradley *et al.* 2003)[99].

Existing studies on this domain have already established that faces can actually activate specific regions of the brain especially the fusiform gyri (Clark *et al.*1996 [100]; George *et al.*1999 [101]; Kanwisher *et al.*1997 [102]; Puce *et al.* 1995 [103]). Emotional expressions in faces have been found to activate several distinct regions involving amygdala, cingulated gyrus, orbitofrontal cortex and also other prefrontal areas (Blair *et al.* 1999 [104]; Breiter *et al.* 1996 [105], Dolan *et al.* 1996 [106]; Morris *et al.* 1996; [107] Nakamura *et al.* 1999)[108]. Often these kinds of activities are automatic by nature because they can arise without requiring explicit judgment of facial expressions and even without awareness about faces especially when faces are masked (Morris *et al.* 1998)[109].

SUMMARY AND CONCLUSION

In this paper, we discussed the role of the human face in influencing cognitive processes of attention by reviewing literature over past 30 years. From initial work summarizing about how attractive faces receive more favourable preferences and how we are more susceptible to changes in infant faces, later work has also been reviewed based on tracking of attractive faces, processing of locations where attractive faces occur, effect of facial cues on our brain and how the human face acts as a potential distractor disrupting attentional processes.

Cross-cultural investigations of differences in cognitive styles suggests that allocation of cognitive resources tends to vary among cultures on the basis of focal objects or background context (Nisbett and Masuda 2001[110]; Nisbett and Miyamoto 2005 [111]).To our knowledge, no other study has been conducted in South Asian population to assess the effect of facial attractiveness on attentional processes. An investigation of this domain with respect to South Asian population would help provide newer insights. Future studies could also further explore the widespread neural networks and circuitry which are involved behind attention towards attractive faces along with a exploring differences in gender responses towards attractiveness amidst ongoing cognitive processes. Another future work would be empirically assessing the role of human face as a distractor in domain of multitasking or divided attention. Multi-tasking is an integral part of life in the 21st century. An interesting aspect would be to see how performance gets affected on a task of divided attention when an attractive face is present in the visual field.

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Conflict of Interest

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