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Is attentional prioritisation of infant faces is unique in humans?: comparative demonstrations by modified dot-probe task in monkeys

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ABSTRACT

Humans innately perceive infantile features as cute. The ethologist Konrad Lorenz proposed that the infantile features of mammals and birds, known as the baby schema (*kindchenschema*), motivate caretaking behaviour. As biologically relevant stimuli, newborns are likely to be processed specially in terms of visual attention, perception, and cognition. Recent demonstrations on human participants have shown visual attentional prioritisation to newborn faces (*i.e.*, newborn faces capture visual attention). Although characteristics equivalent to

22   those found in the faces of human infants are found in nonhuman primates,

23   attentional capture by newborn faces has not been tested in nonhuman

24   primates. We examined whether conspecific newborn faces captured the visual

25   attention of two Japanese monkeys using a target-detection task based on dot-

26   probe tasks commonly used in human visual attention studies. Although visual

27   cues enhanced target detection in subject monkeys, our results, unlike those for

28   humans, showed no evidence of an attentional prioritisation for newborn faces

29   by monkeys. Our demonstrations showed the validity of dot-probe task for

30   visual attention studies in monkeys and propose a novel approach to bridge the

31   gap between human social cognition research and primate research. This

32   suggests that attentional capture by newborn faces is not common to

33   macaques, but it is unclear if experiences of caretaking influence their

34   perception and recognition of infantile appraisal stimuli. We need additional

35   comparative studies to reveal the evolutionary origins of baby-schema

36   perception and recognition.

37

38   **1. Introduction**

39

40   Humans innately perceive infantile features as cute (Alley 1981, 1983;

41   Fullard and Reiling 1976; Sanefuji, Ohgami, and Hashiya 2007; Sprengelmeyer

42   et al. 2009). The ethologist Konrad Lorenz proposed that infantile features,

43   known as baby schema (*kindchenschema*), motivate caretaking behaviour and

44   act as a "social releaser" (Lorenz 1943). He defined baby schema as a set of

45   infantile physical characteristics; these include a round face, large head, large

46 eyes, a high and protruding forehead, chubby cheeks, a small nose and mouth,

47 short and thick extremities, and a plump body shape. Lorenz's theory held that

48 the evolution of this adult perception or social cognition was shaped by the

49 selective advantages of the survival of immature offspring. Several empirical

50 psychological (Alley 1981, 1983; Brosch et al. 2008; Brosch, Sander, and

51 Scherer 2007; Fullard and Reiling 1976; Glocker, Langleben, Lobmaier et al.

52 2010, Ruparel, Loughead, Gur et al. 2009; Hodsoll, Quinn, and Hodsoll 2010;

53 Luo, Lee, and Li 2011; Parsons et al. 2011; Sanefuji, Ohgami, and Hashiya

54 2007), endocrinological (Sprengelmeyer et al. 2009), and neuroimaging

55 (Glocker, Langleben, Ruparel, Loughead, Valdez et al. 2009) studies have

56 supported his ideas. However, all such studies have been conducted in

57 humans. As infantile physical features are present in other mammalian and

58 avian species, it is surprising that research of this sort has been conducted in

59 nonhuman animals only rarely.

60

61   The operation of specialised visual processing underlying perception of and

62 visual attention devoted to newborn faces has been recently reported in

63 humans (Brosch et al. 2008; Brosch, Sander, and Scherer 2007; Hodsoll,

64 Quinn, and Hodsoll 2010; Parsons et al. 2011). It is well known that threat-

65 relevant stimuli, such as angry faces or snakes, automatically evoke an

66 emotional response, likely resulting in the capture of visual attention in humans

67 (LoBue and DeLoache 2008; Öhman 2005; Öhman, Flykt, and Esteves 2001).

68 This suggests that the human brain implements a fear module when the

69 amygdala rapidly detects threat-relevant stimuli such as a fearful face or snake.

70   However, appraisal theories of emotion hypothesise that the human brain is

71   specialised for processing not only threat-relevant but also biologically relevant

72   stimuli (e.g. Scherer 2001). In terms of survival, there is no doubt that newborns

73   are typical examples of biological relevant stimuli with ecological validity.

74   Recently reports of attentional capture by newborn faces in humans suggest

75   that human attentional systems prioritise newborn faces as well as images of

76   snakes (Brosch et al. 2008; Brosch, Sander, and Scherer 2007; Lobmaier et al.

77   2010; Parsons et al. 2011).

78

79   Given considerations of biological relevance, it is plausible that attentional

80   prioritisation would be not restricted to humans. Indeed, in the context of the

81   common foundations for neural processing and the similar social systems

82   shared by human and nonhuman animals (Adolphs 1999), it would be

83   unsurprising to find that what is biologically relevant for humans would also be

84   relevant for nonhuman primates. For example, an equivalent attentional capture

85   by snake stimuli has recently been reported in Japanese macaques (Shibasaki

86   and Kawai 2009). Consistent with Lorenz's predictions and similar to findings in

87   humans, attentional capture by newborn faces may also be observed in

88   monkeys.

89

90   To examine the evolutionary continuity of the human attentional prioritisation

91   of baby schema, we compared the visual attention paid by two female

92   Japanese macaques (*Macaca fuscata*; JM*)* to images of newborn faces with

93   that paid to adult faces using a target-detection task based on the dot-probe

94   task commonly used in human visual attention studies (Brosch et al. 2008;

95   Brosch, Sander, and Scherer 2007; Hodsoll, Quinn, and Hodsoll 2010). The dot-

96   probe task is a well-established paradigm for investigating attentional

97   prioritisation in humans. This task requires participants to detect a small dot-

98   probe target as quickly as possible. The dot-probe target is shown separately

99   on the left and right sides of the screen, and the visual cueing consists of two

100   paired stimuli that are presented briefly before the target appears. When either

101   of the two stimuli captures most of the participant's attention, the target-

102   detection time is decreased. To employ this dot-probe task with monkeys, we

103   used a touch-sensitive screen monitor and conditioned monkeys to touch the

104   target key to signal detection. We determined whether cueing by infant faces

105   influences the time to target detection.

106

107   **2. Materials and methods**

108

109   All procedures complied with the Guide for the Care and Use of Laboratory

110   Primates (Third Edition, the Primate Research Institute, Kyoto University, 2010)

111   and were approved by the Ethics Committee of the Primate Research Institute

112   of Kyoto University (#2012-065).

113

114   *2.1. Subject animals*

115   Two 5-year-old female Japanese macaques (T2152, A2194) participated in

116   the experiments. Both were born in different social groups at the Primate

117   Research Institute of Kyoto University (Japan) and lived with their own mother

118   and other group members. Their original groups were equivalent social

119   structures with wild ones, including several adult males and females and

120   subadult daughters and sons. Both subjects lived in those groups. T2152 was

121   moved to group cages when she was 20 months old, and lived with 5-6 same

122   age peers until 5 years old. A2194 was moved to group cages when she was 14

123   months old, and lived at group cage until 4 years old. After living in group cages,

124   they moved to individual cages, allowing them to visually and vocally interact

125   with other monkeys, but separated from their own group members. They were

126   fed daily with monkey pellets and fruits, and received water freely. A captive

127   Japanese macaque is sexually matured around between 4 and 5 years old,

128   therefore they were sexually matured during our experiments, but were

129   nulliparous with no experience of mating.

130

131   *2.2. Apparatus*

132   The experimental tasks were performed in a custom-made experimental

133   operant box (450 mm W × 450 mm D × 600 mm H) in a sound-attenuating

134   chamber. The monkeys were individually tested in the box. A 15-inch touch-

135   sensitive LCD screen (TSD-CT157-MN, Mitsubishi Electric Engineering, Tokyo,

136   Japan, 1024 × 768 pixels display resolution) was mounted on one side of the

137   experimental box. A universal food dispenser (BUF-310-P100, BIOMEDICA,

138   Osaka, Japan) was placed in the experimental box to provide a piece of sweet

139   potato or raisins as a food reward. The food dispenser was controlled by

140   computers with USB I/O interfaces (DIO-0808TY-USB, CONTEC, Tokyo,

141   Japan). Stimulus presentation and food dispensing were controlled by a

142   custom-made program.

143

144   *2.3. Stimuli*

145   Images of the faces of conspecifics were used as visual cues, and we

146   prepared two stimulus categories: adult females (sexually mature, ≥4 years old)

147   and infant females (<1 year old). All faces, which were unfamiliar to subjects,

148   were oriented frontward, displayed no emotion, and appeared on a uniform

149   black background. All images fit within an area of 300 × 300 square pixels. The

150   average luminance and contrast were adjusted to equivalent values using

151   Adobe Photoshop CS5. Five stimuli were prepared for each of the two stimulus

152   categories (see Fig. 1).

153

154   *2.4. Procedures*

155   Monkeys were required to touch the circle keys on the screen throughout

156   the experiments. At the start of each trial in the training session, one white circle

157   was presented at the centre of the screen as a start key. When the start key

158   was touched, the screen immediately blacked out for 100 ms. After the blackout,

159   a blue circle was displayed on either the left or the right side of the screen as a

160   target key. When a target key was touched, the screen blacked out and the

161   monkey was reinforced with a food reward accompanied by auditory feedback.

162   After reinforcement, a 2000-ms inter-trial-interval (ITI) was inserted, and next

163   trial then started. The monkeys were required to touch the target key within

164   1000 ms. When the monkey did not touch within 1000 ms, the screen blacked

165   out and a buzzer sound was played. After the time out, a 10000-ms ITI was

166   inserted as negative feedback, and the next trial then started. A single training

167   session consisted of 100 trials (50 for the left target, 50 for the right target

168   presented in a randomised order). When >80 % correct responses were

169   recorded in five consecutive sessions, the participants were considered to have

170   learned how to perform the tasks. These five consecutive sessions were used

171   to provide baseline data regarding target detection without visual cues.

172

173   After the baseline sessions, we proceeded to the cued session (Fig. 2).

174   After the start key was touched, a cue was presented for 100 ms. The cue

175   consisted of one infant and one adult face. The paired stimuli were randomly

176   selected from five infant and five adult faces. Following cue presentation, the

177   target key appeared. In infant-valid trials, the target key appeared near the

178   infant's face; in adult-valid trials, the target key appeared near the adult's face

179   (Fig. 1). Half of the trials in each session were infant valid, and the other half

180   were adult valid. Both side-by-side positions (left infant and right adult, left adult

181   and right infant) were used, yielding a total of 100 trials per a session (five

182   infants x five adults x two side-by-side positions x two validity conditions).

183   Presentation orders were randomised. Ten test sessions were conducted with

184   each subject.

185

186   *2.5. Analysis*

187   We measured the reaction times (RTs) from the appearance of the response

188   key to the touch response. Trials that timed out were excluded from the analysis

189   of RTs. RTs for experimental conditions were averaged for each session. First,

190   to examine the effect of cue presentation, we compared the RTs during the five

191   baseline sessions with those during the 10 test sessions with a two-way

192   repeated-measures analysis of variance (ANOVA); we tested for main and

193   interaction effects involving cue presentation (baseline, test) and target position

194   (left, right). Second, to examine the effects of the cue-validity condition (infant

195   valid, adult valid) and target position (left, right) on RTs, we compared RTs

196   under the infant- and adult-valid conditions with a two-way repeated-measures

197   ANOVA; we tested for main and interaction effects involving cue validity and

198   target position. Sessions were treated as error terms in all ANOVAs. The

199   statistical analyses were performed separately for the two subjects. Significance

200   levels were set at $P < 0.05$.

201

202   **3. Results**

203

204   Figure 3 shows the RTs during baseline and cued sessions for each target

205   position (left or right) for the two monkeys. The ANOVAs showed no interaction

206   effects between cue presentation and target position (T2152: $F_{1,13} = 3.68$, $P =$

207   0.08; A2194: $F_{1,13} = 1.86$, $P = 0.20$) but did reveal significant main effects for cue

208   presentation in both subjects (T2152: $F_{1,13} = 6.82$, $P = 0.022$; A2194: $F_{1,13} =$

209   6.61, $P = 0.023$). A significant effect of target position was also observed in

210   A2194 ($F_{1,13} = 37.3$, $P < 0.001$) but not in T2152 ($F_{1,13} = 1.32$, $P = 0.27$). This

211   indicated that the subjects detected targets more rapidly when cues were

212   presented than when they were not.

213

214   Figure 4 shows the RTs for both subjects under the infant- and adult-validity

215   conditions for each target position (left or right) during the cued sessions. The

216   ANOVAs revealed no interactions between cue validity and target position

217   (T2152: $F_{1,27}$ = 0.87, P = 0.36; A2194: $F_{1,27}$ = 0.072, P = 0.79) but did reveal

218   significant main effects for target position in A2194 ($F_{1,27}$ = 85.14, P < 0.001) but

219   not T2152 ($F_{1,27}$ = 0.037, P = 0.85). We found no significant effect for cue validity

220   in either subject (T2152: $F_{1,27}$ = 0.19, P = 0.66; A2194: $F_{1,27}$ = 3.16, P = 0.089).

221   These findings indicate that target detection was not influenced by type of cue.

222

223   **4. Discussion**

224

225   Our data showed that two well-trained monkeys touched the target more

226   rapidly with visual cues than without such cues. This suggests that the visual

227   attention of monkeys was attracted by the visual cues. However, in contrast with

228   the results of the recent study on humans, RTs were not influenced by the type

229   of visual cue. The side bias of target position was found only in A2194,

230   indicating that she always toched targets shown in left side of screens. It might

231   be interesting because the previous studies using dot-probe task in humans

232   reported a similar side bias and concluded that it would be caused by laterality

233   in emotional processing. However, side bias found in A2194 would be caused

234   not by laterality in emotional processing but rather by her handedness. She

235   always touched screen by left hand. Those suggest that the monkeys' attention

236   was not captured by infant faces.

237

238   So far, two major experimental paradigms have been used for behavioural

239   studies in human visual attention. One paradigm is dot-probe tasks which we

240   used here, and the other is visual search task, which requires participants to

241   simply detect a target visual stimulus among a lot of distracter stimuli on the

242   screen as quickly and correctly as possible. If a target stimulus captures the

243   visual attention than distracters, the detection time for visual search would be

244   shortened. Although visual search paradigm has an advantage for simple

245   discussions between participant performance and attentional prioritisation, it

246   would be more difficult for monkeys and other animals to train those tasks.

247   Animals must learn to discriminate a target stimulus from other distracters

248   before testing attentional prioritisations. In dot-probe task, animals only learn to

249   touch a small dot-probe target on the screen as quickly as possible without any

250   discrimination learning. Despite of small sample size, our results confirming the

251   validation of the paradigm would contribute to further comparable experiments

252   in monkeys. For the next step, we need to know how the cue duration

253   influences their visual attention. Here, we used single due duration (100 msec),

254   because one of our purposes was to show comparative results with the

255   previous studies (Brosch, Sander, and Scherer 2007) which used only 100-

256   msec as cue duration. Usually, several cue durations from 100 to 500 msec

257   have been used in dot-probe tasks in human participants. Influence of cue

258   validity on target detection would varies according to cue durations. Longer cue

259   duration might show attentional prioritisation to infant face in monkeys as well.

260   To establish this paradigm more effectively, we will need to know their basic

261   profiles of visual attentions during this paradigm.

262

263   Although attentional prioritisation was not found in monkeys, this does not

264   rule out the possibility that monkeys have a cognitive process specialised for

265   infant stimuli. Recently, using visual paired-comparison tasks, we found a visual

266   preference for infantile features in nonhuman primates that was equivalent to

267   the human preference for baby schema (Sato et al. 2012). We found that

268   monkeys looked at images of infant bodies longer than they looked at those of

269   adult ones and concluded that monkeys preferred images of infants over those

270   of adults. This preference for babies in monkeys would be equivalent to that in

271   humans (Alley 1981, 1983; Glocker, Langleben, Ruparel, Loughead, Gur et al.

272   2009; Glocker, Langleben, Ruparel, Loughead, Valdez et al. 2009; Luo, Lee,

273   and Li 2011; Sanefuji, Ohgami, and Hashiya 2007) and could be explained from

274   an ecological perspective in terms of the prolonged period of infancy that is

275   characteristic of both species. Indeed, monkeys are also born immature and

276   need adult nurturing. However, the psychological process of visual attention

277   differs from that of visual preference. Because preferences for baby schema

278   occur independently of attentional processes, we can conclude that monkeys

279   possess a specialised preference for infants without also demonstrating that

280   they place attentional priority on infants. Preference for infants may constitute a

281   psychological trait that is common to humans and monkeys, whereas attentional

282   prioritisation of infants might be unique to humans.

283

284   Brosch hypothesised that the attentional prioritisation of human baby

285   schema may involve the amygdala as a possible candidate neural substrate

286   (Brosch et al. 2008; Brosch, Sander, and Scherer 2007). Indeed, although

287   numerous studies have confirmed the important role of the amygdala in neural

288   processing involving the prioritisation of biologically relevant stimuli, most

289   previous findings have related to threat-relevant stimuli such as snakes and

290   angry faces rather than to emotionally positive stimuli such as smiling faces (for

291   a review, see Öhman 2005). The perception and recognition of negative

292   affectively arousing stimuli by both humans and monkeys likely involves the

293   amydala. However, the attentional prioritisation of baby schema seems to be an

294   exceptional phenomenon found only in humans, who may have evolved special

295   processing operations that prioritise attention to baby schema in a unique way.

296   In fact, research conducted after Brosch's studies has shown that the

297   attentional prioritisation of baby's faces does not hold for infants of another race

298   (Hodsoll, Quinn, and Hodsoll 2010). Indeed, the attentional prioritisation of baby

299   schema is restricted to babies of one's own race, suggesting that it is not as

300   generalised as are reactions to threat-relevant stimuli. These specialised

301   perceptual traits do not derive from the common ancestor of humans and

302   macaques.

303

304   In contrast to visual attention, cognitive process involved in visual preference

305   would be partly shared by different species. For example, general preference

306   for faces over non-face objects would be shared by nonhuman primates (Sugita

307   2008) and by avian species (Rosa-Salva et al. 2010; 2011) as well, suggesting

308   common cognitive traits between humans and animals. Likely, visual

309   preferences for baby schema may be underpinned by the neural substrates that

310   are common to humans and animals. A recent neuroimaging study in humans

311   showed that baby schema activate the nucleus accumbens, a key structure in

312   the mesocorticolimbic system mediating reward processing and appetitive

313   motivation, as a function of degrees of cuteness (Glocker, Langleben, Ruparel,

314   Loughead, Valdez et al. 2009). Interestingly, baby-schema activation was

315   confirmed in nulliparous women, and it was suggested that brain-reward

316   systems are likely involved in the perceptions of cuteness related to baby

317   schema. This is thought to result in the promotion of human caregiving,

318   irrespective of kinship relationship. Although no empirical evidence of the

319   activation of the nucleus accumbens by baby schema has been reported in

320   monkeys thus far, studies in rats have revealed that the nucleus accumbens

321   plays an important role in maternal behaviour (Champagne et al. 2004). Many

322   behavioural studies of monkeys have suggested that infants, regardless of their

323   fitness, induce caregiving behaviour. Indeed, conspecific and heterospecific

324   adoption of infants has often been observed in nonhuman primates (Thierry and

325   Anderson 1986), and adoption in animals remains completely unexplained in

326   terms of fitness considerations. It seems plausible that a baby would itself

327   automatically provoke the motivation for caregiving. In the context of the recent

328   evidence in monkeys (Sato et al. 2012), it seems plausible that the preference

329   for babies evolved from the common ancestor of humans and macaques.

330

331   In conclusion, our results did not reveal the operation of any special attentional

332   prioritisation for baby schema in monkeys; this contrasts with the results for

333   humans. However, it is too early to conclude that monkeys do not place any

334   kind of attentional prioritisation on infant faces. We must acknowledge several

335   limitations of our present research. First, we tested only two nulliparous females

336   with no experience of caregiving. We should not conclude all from our restricted

337   subjects. In the near future, we must test if exposures to babies or experiences

338   of delivery influence the attentional prioritisation to infant stimuli like humans.

339   Second, context of face stimuli would influence cue validity. Given that

340   attentional prioritisation was found in response to fear-relevant stimuli such as

341   snakes or angry faces, the results may differ if we contextualise the face stimuli.

342   For example, a facial image of an infant screaming may capture monkeys'

343   attention more strongly than a facial image of an adult screaming. It is also

344   possible that infant faces specifically capture the attention of their own mothers.

345   In fact, a recent demonstration in humans revealed that the onset latency of

346   event-related potentials (P300) was shortest when mothers observed their own

347   infant crying, suggesting that the context of an infant face influences attentional

348   prioritisation (Doi and Shinohara 2012). Future research with monkeys should

349   consider the context of stimulus faces. Although why humans evolved this

350   attentional prioritisation remains unclear, it may be related to the prolonged

351   immaturity of newborn humans. There is no doubt that human babies are the

352   least mature among the baby animals. Indeed, during the first years of life,

353   human babies cannot survive without parental care. Attentional prioritisation

354   may have evolved as a survival strategy to counter this immaturity. We need to

355   conduct additional comparative studies to reveal the evolutionary origins of

356   baby-schema perception and recognition.

357

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428

429   **FIGURE LEGENDS**
430

431   Figure 1. Stimuli used in experiments. (Top) Adult faces. (Bottom) Infant faces.
432

433   Figure 2. Schematic representation of the target-detection tasks for (A) baseline
434   sessions, and (B) cued sessions. A trial under the right-target condition was
435   conducted in the baseline session, and trials under the infant-valid and adult-
436   valid conditions with the target on the left were conducted in the cued sessions.
437   On the screen, the circles for the start and target keys were both set at

438   153 pixels in diameter, and the horizontal distance between the left and right

439   key positions (from centre to centre) was set at 724 pixels. The horizontal

440   distance between paired stimuli was also adjusted to correspond to that

441   between the response keys.

442

443   Figure 3. Reaction times (RTs) for cue-presentation and target-position

444   conditions for T2152 (top) and A2194 (bottom). Error bars represent mean

445   values ± 95% confidence intervals.

446

447   Figure 4. Reaction times (RTs) under the validity and target-position conditions

448   for T2152 (top) and A2194 (bottom).

449

450

Figure 1

Start key

No cue (100 msec)

Target key
Reaction required
within 1000 msec

Inter-trial Interval(ITI)
2000 or 10000 msec

(A) Baseline session

Start key

Cue (100 msec)
Infant valid

or

Cue (100 msec)
Adult valid

Target key
Reaction required
within 1000 msec

ITI
2000 or 10000 msec

(B) Cued session

Figure 2

Figure 3

Figure 4