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2 **Is attentional prioritisation of infant**

3 **faces is unique in humans?:**

4 **comparative demonstrations by**

5 **modified dot-probe task in monkeys**

6

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14 **ABSTRACT**

15 Humans innately perceive infantile features as cute. The ethologist Konrad

16 Lorenz proposed that the infantile features of mammals and birds, known as the

17 baby schema (*kindchenschema*), motivate caretaking behaviour. As biologically

18 relevant stimuli, newborns are likely to be processed specially in terms of visual

19 attention, perception, and cognition. Recent demonstrations on human

20 participants have shown visual attentional prioritisation to newborn faces (*i.e.*,

21 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, Loughhead, 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, Loughhead, 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 touched 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 cue 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 amygdala. 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 Loughhead, 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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365

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367

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426

427

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 \pm 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

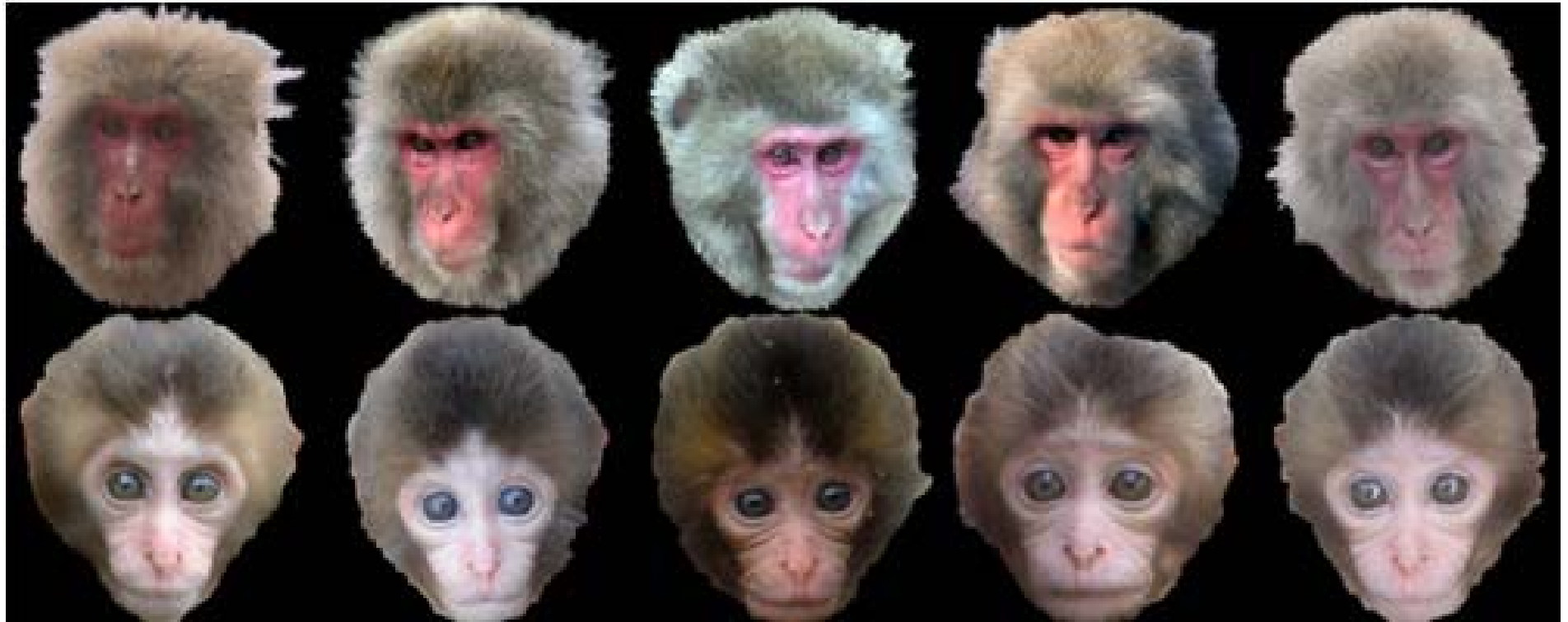


Figure 1

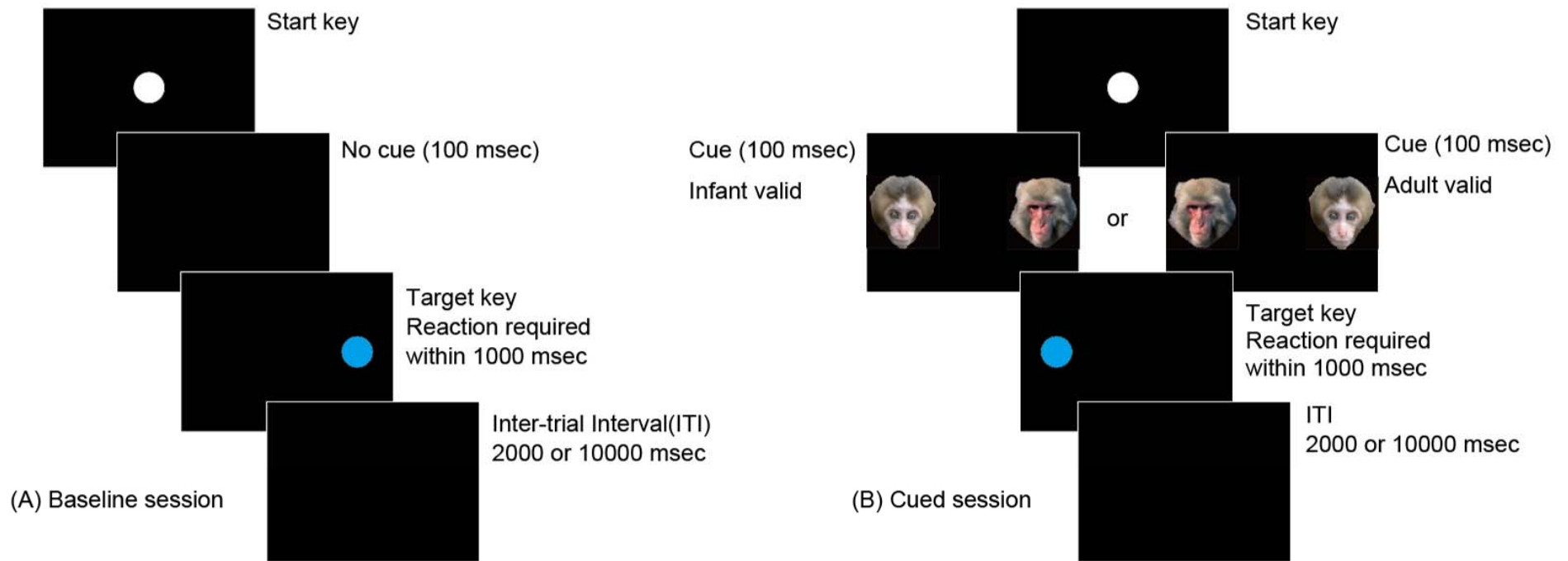


Figure 2

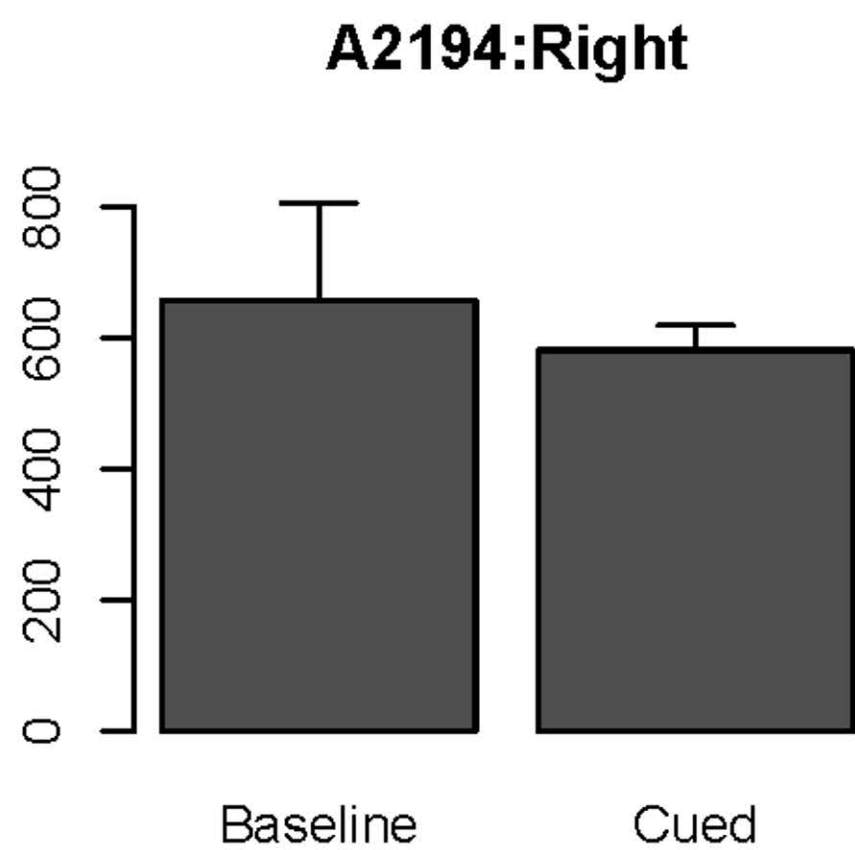
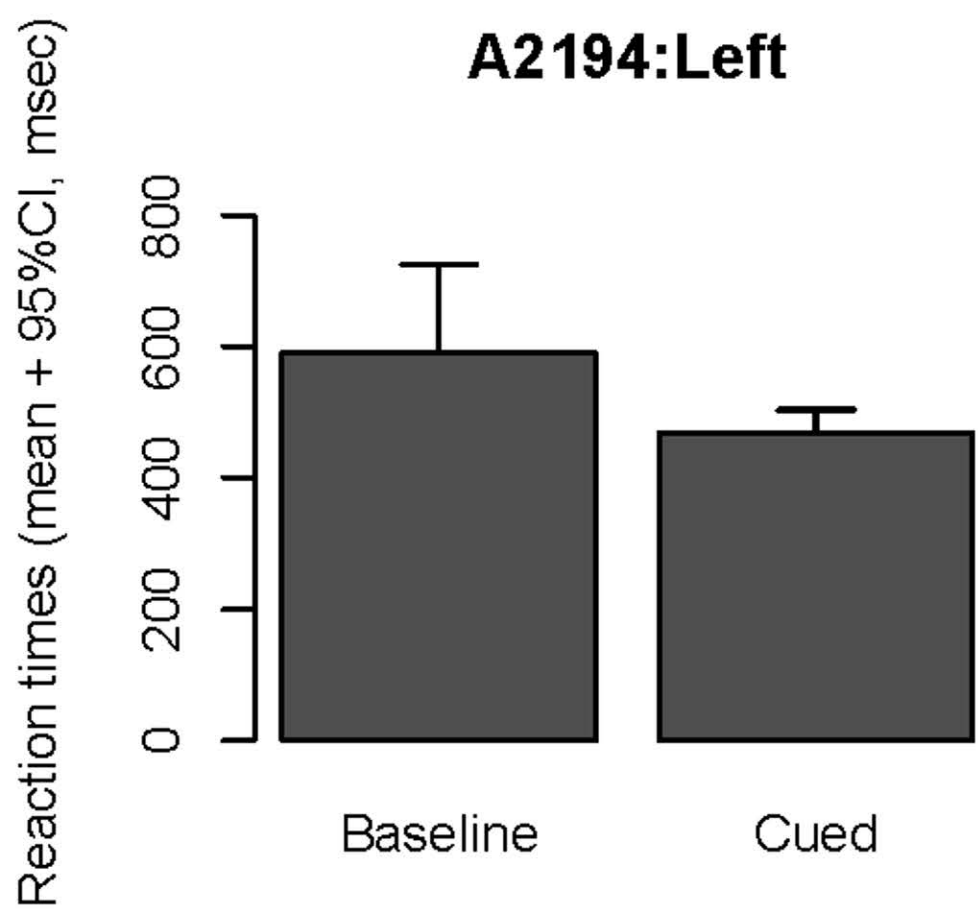
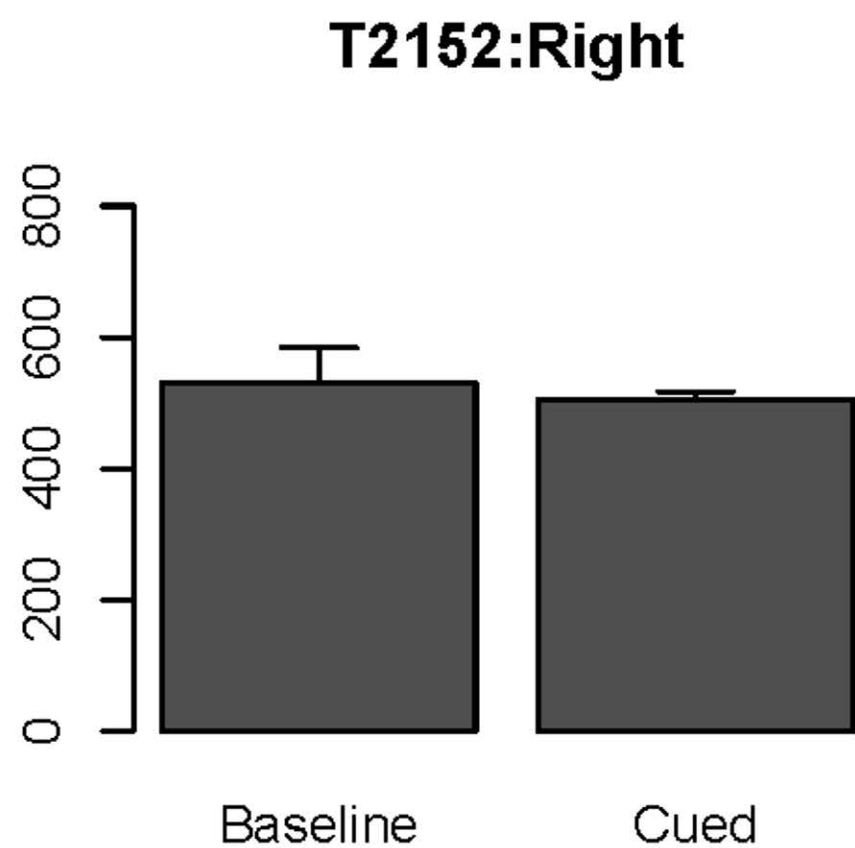
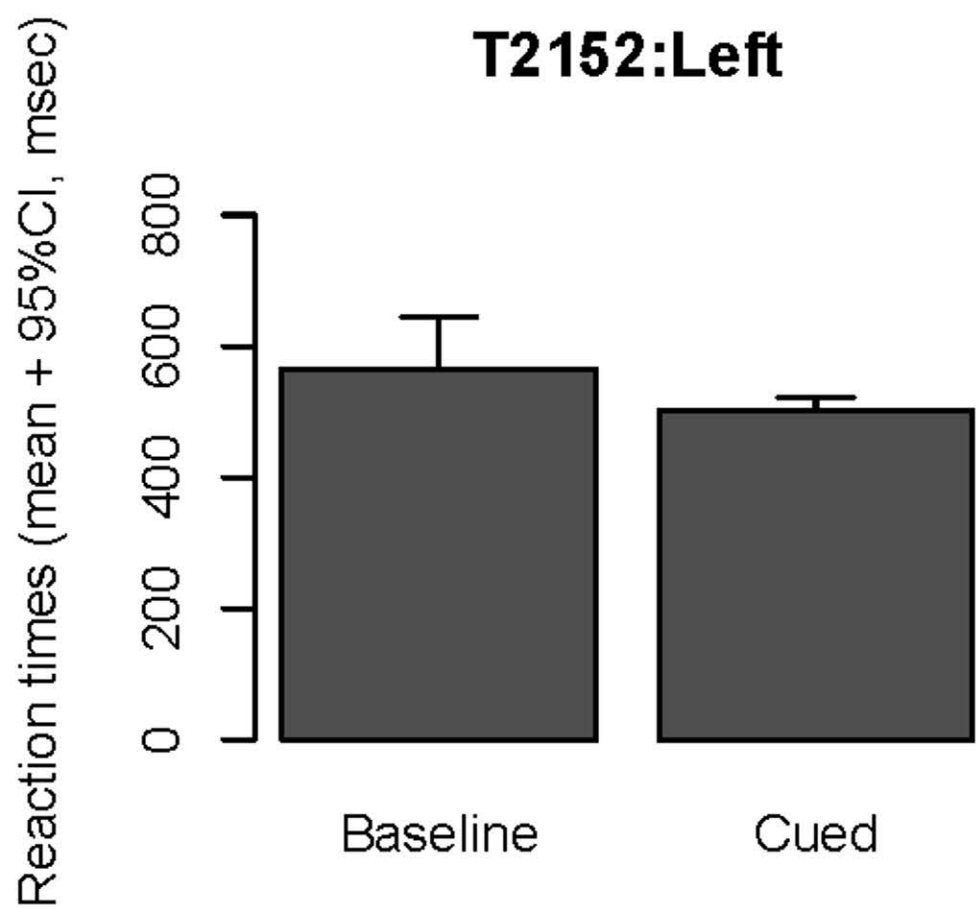


Figure 3

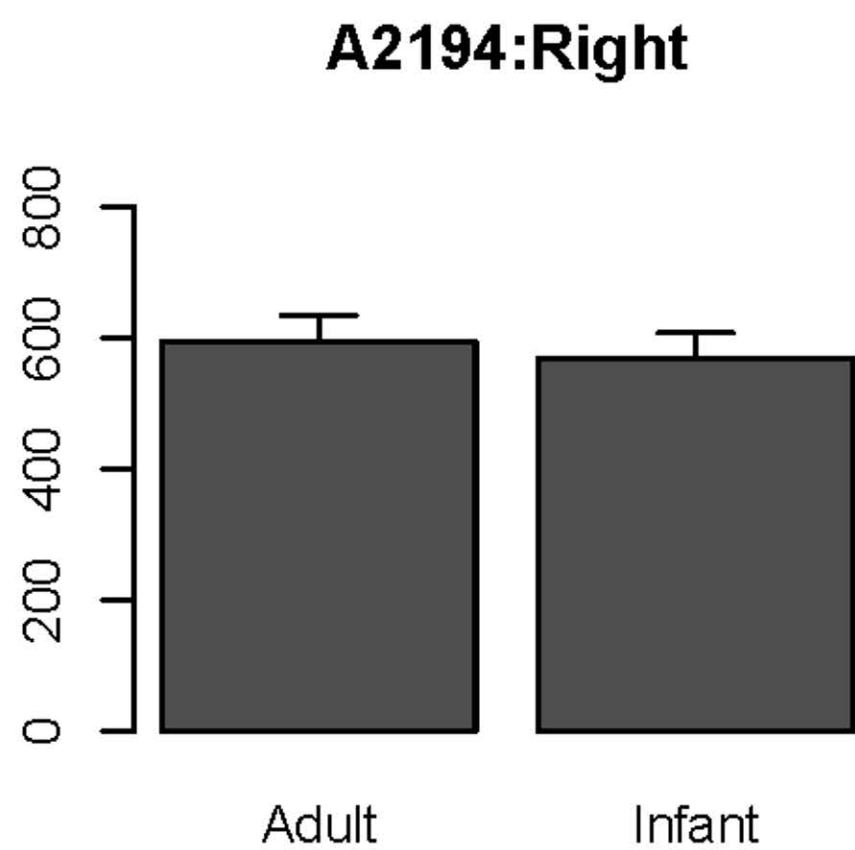
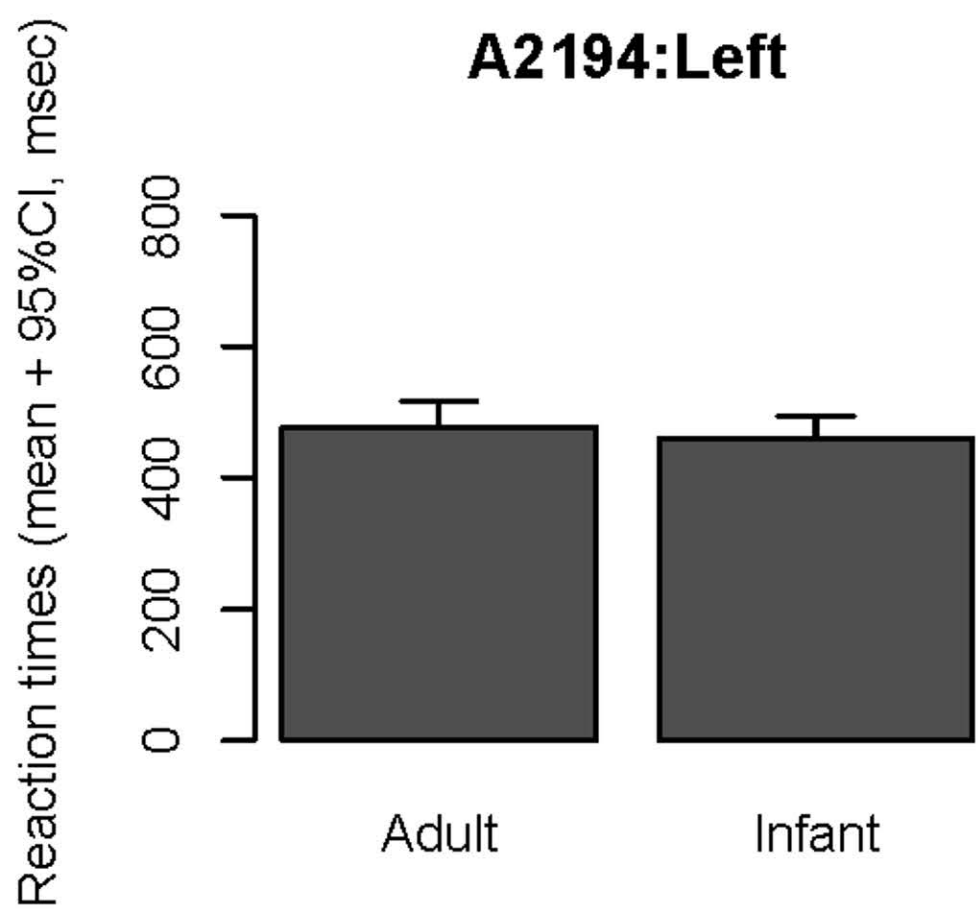
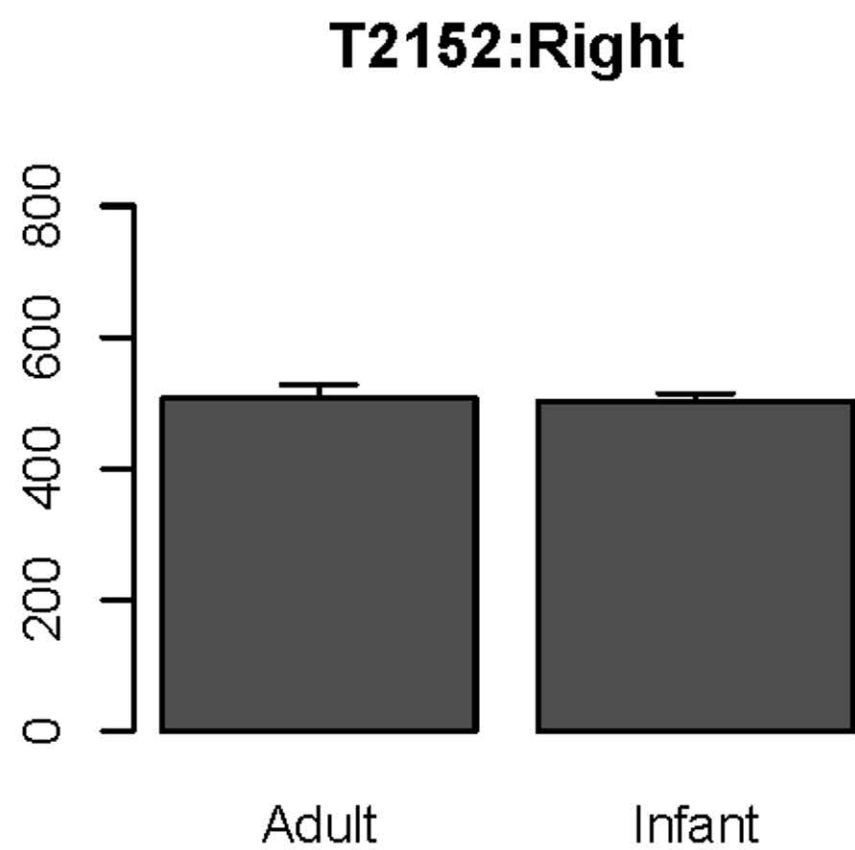
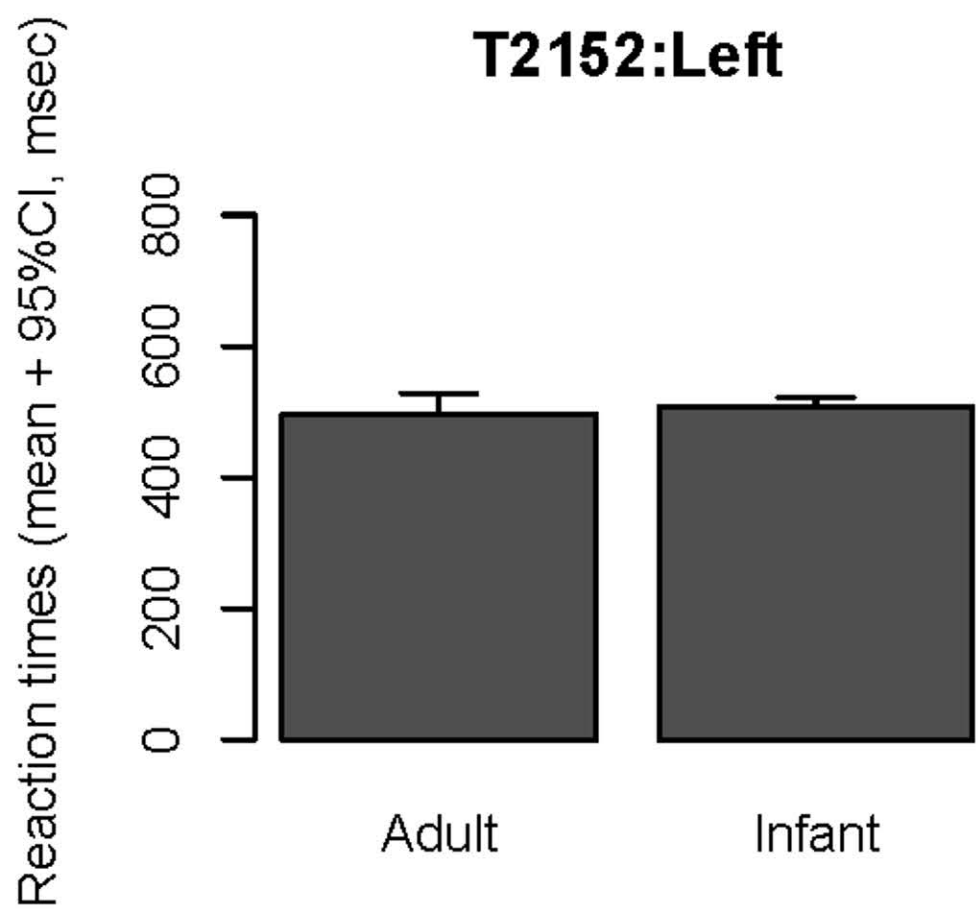


Figure 4