

Electronic Supplemental Materials

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Developmental shifts in social cognition:
Socioemotional biases across the lifespan in rhesus monkeys

Behavioral Ecology and Sociobiology

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Study 1 Supplementary Results

Negativity bias difference scores

As reported in the main text, we used linear mixed models to examine changes in negativity bias using a simple difference score (Threat looking time – Neutral looking time); parameters from the full model are reported in Table S1.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>t</i>	<i>P</i>
Photo set (reference = set 1)	-0.068	0.235	-0.291	> 0.77
Outgroup (reference = not outgroup)	0.422	0.486	0.868	> 0.38
Sex (reference = female)	-0.443	0.235	-1.886	= 0.059
Age (linear in years)	0.078	0.028	2.750	< 0.01
Photo face (reference = female)	1.018	0.435	2.341	< 0.05
Age X Photo face	0.044	0.051	0.852	> 0.39

Table S1: Factors influencing socioemotional negativity bias (Study 1): simple difference scores. Predictors from the full linear mixed model examining difference scores (Threat looking time – Neutral looking time). *Age*, *Photo face*, and the *Age X Photo face* interaction were added to successive models to test their importance. Baseline reference for predictors indicated in table.

We then also examined each subject's individual negativity bias using a weighted difference score (Threat looking time – Neutral looking time / Neutral looking time); thus, more positive scores indicates greater relative attention to the negative stimuli. As with the simple difference score reported in the main text, this weighted difference score varied with age for both the female stimuli (juveniles: -0.12 ± 0.06 ; adults: 0.28 ± 0.11 ; older adults: 0.09 ± 0.17) and the male stimuli (juveniles: 0.37 ± 0.19 ; adults: 1.46 ± 0.36 ; older adults: 1.78 ± 0.68).

To analyze the weighed difference scores, we first created a basic linear mixed model accounting for *photo set*, *outgroup photos*, subject's *sex*, and *subject* (as a random factor). In a full model, we also added *photo type* (male versus female stimuli), *age*, and an interaction between *age X photo type*; the full model had better fit than the base model type [$\chi^2 = 38.46$, $df = 3$, $p < 0.0001$]. We then examined each predictor. Including *photo type* to contrast negativity biases for the two types of stimuli improved model fit compared to the base model [$\chi^2 = 27.00$, $df = 1$, $p < 0.0001$]: monkeys exhibited greater relative attention to the male threat stimuli than the female threat stimuli. The key question for socioemotional selectivity was whether these difference scores reliably changed with age, indicating shifts in interest and attention to negative stimuli. In fact, fit was further improved in a model also including *age* [$\chi^2 = 6.53$, $df = 1$, $p < 0.05$]: older monkeys showed more positive difference scores, indicating greater attention to the emotional threat stimuli, than did younger monkeys. Finally, we then added the interaction between *age X photo type* to test whether this shift to greater interest in negative images differed for the male versus female photos. This improved model fit [$\chi^2 = 4.92$, $df = 1$, $p < 0.05$] indicating more exacerbated interest in the male threat stimuli compared to female threat stimuli with age (see Table S2 for parameters from the full model).

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>t</i>	<i>P</i>
Photo set (reference = set 1)	0.021	0.164	0.129	> 0.89
Outgroup (reference = not outgroup)	0.082	0.339	0.241	= 0.81
Sex (reference = female)	-0.350	0.164	-2.135	< 0.05
Age (linear in years)	0.018	0.020	0.936	> 0.34
Photo face (reference = female)	0.364	0.303	1.199	> 0.23
Age X Photo face	0.079	0.036	2.209	< 0.05

Table S2: Factors influencing socioemotional negativity bias (Study 1): weighted difference scores. Predictors from the full linear mixed model examining weighted difference scores (Threat looking time – Neutral looking time / Neutral looking time). *Age*, *Photo face*, and the *Age X Photo face* interaction were added to successive models to test their importance. Baseline reference for predictors indicated in table.

Female negativity bias and study completion

As reported in the main text, we also used linear regressions to examine if negativity bias towards female stimuli (indexed by difference scores) differed for subjects that only completed the first two trials of the study (female photos) compared to those who went on to complete all four trials (female and male photos); the parameters from the full model are reported in Table S3.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>t</i>	<i>P</i>
Photo set (reference = set 1)	-0.544	0.280	-1.943	= 0.053
Outgroup (reference = not outgroup)	0.616	0.584	1.054	> 0.29
Sex (reference = female)	-0.316	0.280	-1.129	> 0.26
Age (linear in years)	0.075	0.037	2.040	< 0.05
Expression (reference = neutral)	-0.107	0.496	-0.215	> 0.83
Age X Expression	0.025	0.055	0.543	> 0.65

Table S3: Factors influencing negativity bias: completion rates (Study 1). Predictors from the full linear mixed model examining simple difference scores for female photos. *Completion rate* and the *Age X Completion* interaction were added to successive models to test their importance. Baseline reference for predictors indicated in table.

Study 2 Supplementary Results

Negativity bias difference score

As reported in the main text, we used linear regression to examine changes in positivity bias with age using a simple difference score (Affiliative looking time – Neutral looking time); the parameters from the full model are reported in Table S4.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>t</i>	<i>P</i>
Sex (reference = female)	0.068	0.332	0.204	> 0.83
Age (linear in years)	-0.061	0.036	-1.705	= 0.091
Order (reference = Affiliative first)	-2.505	0.475	-5.270	< 0.0001
Age X Order	0.084	0.052	1.630	= 0.106

Table S4: Factors influencing socioemotional positivity bias (Study 2): simple difference scores. Predictors from the full linear mixed model examining simple difference scores (Affiliative looking time – Neutral looking time). *Age*, *Order*, and the *Age X Order* interaction were added to successive models to test their importance. Baseline reference for predictors indicated in table.

We then also examined each subject's individual positivity bias using a weighted difference score (Affiliative looking time – Neutral looking time / Neutral looking time); thus, more positive scores indicate greater relative attention to the positive stimuli. Overall, juveniles exhibited an average weighted difference score of 0.13 ± 0.07 ; adults of 0.63 ± 0.31 ; and older adults of 0.48 ± 0.27 . To analyze positivity bias difference scores, we first created a basic linear model accounting for *trial order* (affiliative versus neutral photo first), and subject's *sex*. This revealed a strong effect of order [estimate = -1.10, SE = 0.19, $t = -5.702$, $p < 0.001$]: monkeys showed a greater positivity bias if they saw the affiliative photo first compared to the neutral photo first. Model fit was marginally improved in a full model also incorporating *age* and an *age X order* interaction [$\chi^2 = 5.82$, $df = 2$, $p = 0.055$]. Examining these predictors individually, model fit was not improved by adding *age* to the base model [$\chi^2 = 2.47$ $df = 1$, $p > 0.11$, n.s.]: monkeys exhibited similar positivity biases across ages, the main test of changes in socioemotional biases. Finally, including an *age X order interaction* revealed a trend for improved model fit [$\chi^2 = 3.35$, $df = 1$, $p = 0.067$]; this trend suggests that, unlike in the simple difference score, here older monkeys trended towards have a greater positivity bias if they viewed the positive photo first (see Table S5 for parameters from the full model). However, as the comparison of the full model to the basic model did not improve overall fit, this suggests inconsistent effects of age on responses.

<i>Factor</i>	<i>Estimate</i>	<i>S.E.</i>	<i>t</i>	<i>P</i>
Sex (reference = female)	0.165	0.195	0.849	> 0.39
Age (linear in years)	0.050	0.021	2.384	< 0.05
Order (reference = Affiliative first)	-0.709	0.278	-2.549	< 0.05
Age X Order	-0.054	0.030	-1.806	= 0.07

Table S5: Factors influencing socioemotional positivity bias (Study 2): weighted difference scores. Predictors from the full linear mixed model examining weighted difference scores (Affiliative looking time – Neutral looking time / Neutral looking time). *Age*, *Order*, and the *Age X Order* interaction were added to successive models to test their importance. Baseline reference for predictors indicated in table.

Supplemental Video Caption

Video S1: Negative Stimuli. The demonstrator (E1) reveals two successive photos (neutral expression and threat expression), filmed from the perspective of the monkey. An example monkey looking response is shown at the end of the clip.