

Supplementary materials S

Table S1

	Loser	Winner	Observed rank	Calculated rank (DS)
Ylang	18	30	L	L
Adele	32	13	L	L
Rach	0	21	H	H
Ybbi	0	8	H	H
Blossom	0	33	H	H
Tes	1	7	L	L
Aqua	4	5	L	L
Saphy	0	8	H	H
Tallulah	0	34	H	H

A blind observer recorded agonistic interactions (winner/loser) between a focal female and other members of the group during the training and test sessions. Agonistic behaviours included threats (e.g. open mouth threat), displacements (i.e. a macaque approaches another who departs immediately), chases, and physical conflict (e.g. bite, slaps). If the female never lost against other females, she was considered as high ranked (H), otherwise she was considered lower ranked (L). Ranks obtained from David's Scores (DS) were calculated in 2016. They were also based on agonistic interactions between females (see Supplementary S2 for more details). These calculated ranks were regularly monitored and updated during observations and training sessions by caretakers. The mother's rank was applied to females which couldn't be assessed in 2016.

Training phases

Training phase 1

As none of the macaques had experience with touchscreen experiments prior to the beginning of the data collection, all the macaques had to complete two training phases. The first training phase used a rectangular transparent Plexiglas sheet (42 x 30 cm) with a plastic red square target (10 x 12 cm) moved by hand. Monkeys were progressively rewarded for approaching the Plexiglas sheet, touching the target and following it as it moved. This phase was judged as complete if the macaques followed the target 20 times in a row. Two females did not complete this training stage as they gave birth during the training period, two males could not reach the success criterion.

Training phase 2

After completion of the first training phase, the touchscreen was introduced. The aim of training phase 2 was to be trained to touch a target on the screen.

Stimuli

The target was a red (RGB 255, 0, 0) rectangle of a maximum of 1200 x 1000 pixels (ca. 32 x 26 cm) and was gradually reduced to 360 x 500 pixels (ca. 10 x 13 cm).

General Procedure

When the program was launched, the experimenter entered the name of the individual, the number of trials per session, the size of the target and the time limit to complete the task. Every session was initiated by the subject touching a red cross located in the centre of the screen, starting the time recording. Then, the target was displayed in the middle of a white background (RGB 255, 255, 255). For the first 30 trials a picture of peanuts was displayed inside the target to motivate the macaques to touch it. Once the subject touched the target, a high-pitched chime (composed of 3 sound frequencies: 800, 1300 and 2000 Hz) was played, the timer was stopped, and the reward was given. After an inter-trial of 200 ms, with only the white background displayed, the next trial was presented. Based on a pilot study (N = 4 subjects), we set up a maximum response time of 35 s. This time period allowed the subject to display a behavioural response, control it, and continue the task. If the subject left the testing area or was not focusing attention on the screen the session was aborted. If the target was not touched within the time limit (35 s), the timer was paused, a red cross appeared in the centre of the screen until the session was resumed by touching it. The size of the target was gradually reduced to 360 x 500 pixels (ca. 10 x 13 cm). Once the macaques performed successfully 20 times in a row with the target in the centre of the screen, the target was displayed randomly at the far left or right of the screen. This phase was judged as complete if the macaque followed the target 20 trials in a row. If the subject stayed inactive for more than 5 min the session was stopped and continued the next testing day, if the subject did not participate for three testing days in a row the subject was excluded from the task. The training phase 2 was completed by 21 subjects (12 males, 9 females) who therefore progressed to the experimental phase. Six subjects abandoned this training phase as they stayed at distance from the screen or gave birth in the meantime.

Distraction task

Table S2

All sessions, males and females:

a) Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model sex*stimulus	7		
Model optimum	10	51.517	3.797e-11 ***

	Df	Chisq	Pr(>Chisq)
Model session	9		
Model optimum	10	10.931	9.458e-04***

	Df	Chisq	Pr(>Chisq)
Model order of blocks	9		
Model optimum	10	21.802	3.024e-06 ***

	Df	Chisq	Pr(>Chisq)
Model trial	9		
Model optimum	10	21.408	3.711e-06 ***

Between the optimum model and the baseline ($\chi^2_1 = 62.624$, $P = 1.317\text{e-}11$).

b) Variable having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	10		
Model age	11	1.607	0.205

Result of the anovas using the backward regression method for the Distraction control score in all the sessions.
a) Variables having a significant effect on the models: interaction sex*stimulus (if it was either a picture or no picture), session, the order of the blocks and the trial number. The model optimum contains all variables having a significant effect on the model. b) The variable age had no significant effect on the models.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S3

a) Females only

Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model trial	6		
Model optimum	7	7.773	0.005 **

	Df	Chisq	Pr(>Chisq)
Model session	6		
Model optimum	7	9.768	0.002 **

	Df	Chisq	Pr(>Chisq)
Model order of blocks	6		
Model optimum	7	8.89	0.002**

Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	7		
Model age	8	0.129	0.719
Model rank	9	0.024	0.877
Model type of picture	12	5.721	0.126

Result of the anovas between models using the backward regression method for the Distraction control score. For females, trial, session and order of blocks had a significant effect on the models.

* p < 0.05, ** p < 0.01, *** p < 0.001

b) Males only

Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model type of pictures	6		
Model optimum	9	26.553	7.306e-06 ***

	Df	Chisq	Pr(>Chisq)
Model order of blocks	8		
Model optimum	9	29.822	1.598e-05 ***

	Df	Chisq	Pr(>Chisq)
Model trial	8		
Model optimum	9	9.0531	0.003 **

Between the optimum model and the baseline ($\chi^2_1 = 29.822$, N=21, P = 1.598e-05 ***).

Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	9		
Model age	10	2.924	0.087
Model session	11	1.481	0.224

Result of the anovas between models using the backward regression method for the Distraction control score. For males, the variable type of picture and the variable trial and order of blocks had a significant effect on the models.

Table S4

a) Males and females, Block 1, all sessions

	Estimate	Std. Error	z value	Pr(> z)
Control - Neutral	-3.838	3.958	-0.970	0.7606
Object - Neutral	-2.643	5.415	-0.488	0.9604
Threat - Neutral	14.506	5.023	2.888	0.0203 *
Object - Control	1.194	4.529	0.264	0.9933
Threat - Control	18.344	4.145	4.425	<0.001 ***
Threat - Object	17.150	5.553	3.088	0.0104 *

b) Males, all sessions

	Estimate	Std. Error	z value	Pr(> z)
Control - Neutral	-15.826	2.984	-5.304	<1e-04***
Object - Neutral	0.449	3.068	0.146	0.999
Threat - Neutral	-2.863	3.115	-0.919	0.795
Object - Control	16.276	3.014	5.400	<1e-04***

<i>Threat - Control</i>	12.963	3.032	4.276	<1e-04***
<i>Threat - Object</i>	-3.312	3.120	3.1197	0.713

c) Females, all sessions

	<i>Estimate</i>	<i>Std. Error</i>	<i>z value</i>	<i>Pr(> z)</i>
<i>Control - Neutral</i>	-3.788	2.620	-1.454	0.466
<i>Object - Neutral</i>	0.890	2.620	0.340	0.987
<i>Threat - Neutral</i>	2.052	2.655	0.773	0.867
<i>Object - Control</i>	4.679	2.572	1.819	0.264
<i>Threat - Control</i>	5.841	2.597	2.249	0.110
<i>Threat - Object</i>	1.1622	2.592	0.448	0.970

Result of the Tukey HSD test comparing the normalized Distraction control score for each type of picture: Control (no picture presented), Neutral (a picture of a neutral conspecific face presented), Threatening (a picture of the face of a threatening conspecific is presented), Object (a picture of an object). For males and females pooled together for block 1, all sessions (a), for males, all sessions (b) and for females, all sessions (c).

*** $p < 0.001$

Go/No-go

Table S5

Accuracy on a trial

For males and females:

Predictor for success	Df	Chisq	Pr(>Chisq)
Baseline	2		
Model trial	3	0.396	0.529
Model session	4	0.507	0.476
Model sex	5	0.002	0.963
Model age	6	0.000	0.993

Result of the anovas between models using the backward regression method for the success on a No-go trial in the Go/No-go task. None of the variables had a significant effect on the model.

Table S6

Response latency

For males and females:

Predictor for log(response latency)	Df	Chisq	Pr(>Chisq)
Baseline	3		
Model age	4	0.821	0.365
Model session	5	0.713	0.398
Model trial	6	0.301	0.583
Model sex	7	0.260	0.610

Result of the anovas between models using the backward regression method for the success on a No-go trial in the Go/No-go task. None of the variables had a significant effect on the model.

Table S7

Accuracy on a trial

For females only:

Variables having no significant effect on the model:

Predictor for success	Df	Chisq	Pr(>Chisq)
Model optimum	3		
Model trial	4	3.143	0.076
Model age	5	0.358	0.550
Model rank	6	0.055	0.814

Variable having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Baseline	9		
Model session	10	21.408	3.711e-06 ***

Result of the anovas, only in females, between models using the backward regression method for the success on a No-go trial in the Go/No-go task. The variable session had a significant effect on the model.

For males only:

Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Baseline	2		
Model session	3	0.59	0.44
Model trial	4	0.30	0.58
Model age	5	0.19	0.67

Result of the anovas, only in males, between models using the backward regression method for the success on a No-go trial in the Go/No-go task. None of the variables had a significant effect on the model.

Table S8

Accuracy on a trial

No-go trial

Predictor	FEMALES				MALES			
	Estimate	Std. Error	z value	Pr(> z)	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-0.243	1.252	-0.194	0.846	-0.05	0.53	-0.09	0.92
Age	-0.075	0.119	-0.632	0.527	0.02	0.05	0.44	0.66
Rank (low)	-0.191	0.811	-0.235	0.814				
Trial	0.017	0.009	1.769	0.077	0	0.01	-0.55	0.59
Session	0.172	0.08	2.152	0.031*	-0.05	0.06	-0.76	0.45

Results of the GLMM, only in females and only in males for accuracy on a trial for the Go/No-go task. Explanatory variables were individual characteristics (age and rank) and the trial and the session numbers. All full models

included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method.

Table S9

Response latency

<i>For females only:</i> Predictor for log(response latency)	Df	Chisq	Pr(>Chisq)
Model optimum	4		
Model session	5	1.274	0.259
Model age	6	0.532	0.466
Model rank	7	0.057	0.811

	Df	Chisq	Pr(>Chisq)
Baseline	9		
Model trial	10	4.4367	0.0351*

Result of the anovas, only in females, between models using the backward regression method for the response latency on a No-go trial in the Go/No-go task. The variable trial had a significant effect on the model.

Table S10

Response latency

For females only

Predictor	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	7.999	0.177	45.168	0.000
rank (low)	0.021	0.114	0.188	0.858
age	0.010	0.017	0.592	0.580
trial	-0.003	0.001	-2.118	0.035
session	-0.013	0.012	-1.096	0.274

Results of the GLMM, only in females, for the response latency on a No-go trial in the Go/No-go task. Explanatory variables were individual characteristics (age and rank) and the trial and the session numbers. All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method.

Reversal learning

Table S11

Number of trials to learn the rules

Males and females:

a) Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model rule	3		
Model optimum	4	32.989	9.267e-09 ***

	Df	Chisq	Pr(>Chisq)
Model age	3		
Model optimum	4	4.5263	0.0334*

Between the optimum model and the baseline ($\chi^2_1 = 37.514$, N=19, P = 7.146e-09 ***)

b) Variables having no significant effect on the model:

Predictor	Df	Chisq	Pr(>Chisq)
Model optimum	4		
Model sex	5	0.427	0.513

Interaction between rule and age were tested with anovas between the models with rule* and rule + age as independent variable ($\chi^2_1 = 0.101$, N=19, P = 0.751).

Result of the anovas using the backward regression method for the number of trials to learn the rules. a) Variables having a significant effect on the models: rule and . The model optimum contains all variables having a significant effect on the model. b) The variable sex had no significant effect on the models.

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S12

Number of trials to learn the rules

a) For females: Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model rule	3		
Model optimum	4	264.1	< 2.2e-16 ***

Between the optimum model and the baseline ($\chi^2_1 = 37.514$, N=19, P = 7.146e-09 ***1.09e-12).

b) Variables having no significant effect on the model:

Predictor	Df	Chisq	Pr(>Chisq)
Model optimum	3		
Model age	4	1.578	0.209
Model rank	5	0.106	0.745

Result of the anovas, only in females, using the backward regression method for the number of trials to learn the rules. a) Variables having a significant effect on the models: rule and age. The model optimum contains all variables having a significant effect on the model. b) Variables having no significant effect on the models (age and rank).

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S13

Number of trials to learn the rules

For females:

Predictor Number of trials	Estimate	Std. Error	z value	Pr(> t)
(Intercept)	5.302	0.326	16.244	0.000
rank	0.100	0.306	0.327	0.744
Age	0.047	0.044	1.072	0.284
Rule (reversed)	-0.848	0.054	-15.571	0.000***

Results of the GLMM, only in females, for the number of trials to learn the rules in the Reversal learning task. Explanatory variables were individual characteristics (age and rank) and the type of rule (the reversed rule against the acquisition rule). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method. The variable rule had a significant main effect on the models.

Table S14

Accuracy on a trial

Males and females:	Df	Chisq	Pr(>Chisq)
<i>Baseline</i>	2		
<i>Model session</i>	3	9.072	0.004**
<i>Model age</i>	4	3.460	0.063
<i>Model rule</i>	5	3.376	0.066
<i>Model sex</i>	6	1.556	0.212
<i>Model trial</i>	7	1.155	0.283

Result of the anovas between models using the backward regression method for the accuracy on a trial in the Reversal learning task. The variable session had a significant effect on the model.

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S15

Predictor	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	0.932	0.204	4.568	0.000
Rule (reversed)	-0.137	0.071	-1.937	0.053
Sex (female)	-0.182	0.133	-1.364	0.173
Age	-0.034	0.016	-2.420	0.015
Session	0.052	0.018	2.863	0.004**
Trial	0.002	0.003	0.775	0.438

Results of the GLMM for the probability of success on a trial in the reversal learning task. Explanatory factors were divided in 2 categories of determinants: individual characteristics (sex and age) and experimental determinants (acquisition rule or reversed rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, z-value and p-value using maximum likelihood method. The variable session had a significant main effect on the models.

* p < 0.05, ** p < 0.01

Table S16

Accuracy on a trial

For the females:

	<i>Df</i>	<i>Chisq</i>	<i>Pr(>Chisq)</i>
<i>Baseline</i>	2		
<i>Model session</i>	3	6.042	0.014*
<i>Model rank</i>	4	0.252	0.616
<i>Model rule</i>	5	0.283	0.595
<i>Model trial</i>	6	0.084	0.772
<i>Model age</i>	7	0.021	0.885

Result of the anovas, only in females, between models using the backward regression method for the accuracy on a trial in the Reversal learning task. The variable session had a significant effect on the model.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S17

Accuracy on a trial

For the females: Predictor Number of trials	Estimate	Std. Error	z value	Pr(> t)
(Intercept)	0.368	0.296	1.246	0.213
Rule (reversed)	0.065	0.117	0.554	0.580
rank (low)	0.119	0.206	0.575	0.565
Age	0.004	0.029	0.145	0.885
Session	0.062	0.025	2.522	0.012*
Trial	0.001	0.004	0.292	0.770

Results of the GLMM, only in females, for the probability of success on a trial in the reversal learning task. Explanatory factors were divided in 2 categories of determinants: individual characteristics (age and rank) and experimental determinants (acquisition rule or reversed rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, z-value and p-value using maximum likelihood method. The variable session had a significant main effect on the models.

* $p < 0.05$, ** $p < 0.01$

Table S18

Number of taps on the wrong stimulus

Males and females:

a) Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model session	5		
Model optimum	6	13.819	2.02-04***
	Df	Chisq	Pr(>Chisq)
Model trial	5		
Model optimum	6	5.999	1.140e-02*

	Df	Chisq	Pr(>Chisq)
Model rule	5		
Model optimum	6	9.043	2.638-03**

Between optimum model and baseline ($\chi^2_1 = 31.024$, $N=19$, $P = 9.264e-06$ ***).

b) Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	6		
Model age	7	2.573	0.109
Model sex	8	0.472	0.492

Result of the anovas between models containing variables having significant effect for the log 10 of the number of taps on a successful trial. a) Variables having a significant effect on the models: session, trial and rule. The model optimum contains all variables having a significant effect on the model. b) Variables having no significant effect on the models (age and sex).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S19

Log10 of Number of taps when trial was failed

Predictor	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.817	0.035	23.571	9.052e-16
Rule (reversed)	0.039	0.014	2.888	0.004**
Sex (female)	-0.013	0.023	-0.573	0.575
Age	0.003	0.003	1.094	0.296
Trial	-0.001	0.001	-2.454	0.014*
Session	-0.013	0.003	-3.795	1.632e-04***

Results of LMMs for the number taps when a trial was failed. Explanatory factors were divided in 2 categories of determinants: individual characteristics (sex and age) and experimental determinants (acquisition rule or reversed rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method. The variables in bold had a significant effect on the models.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S20

Number of taps on the wrong stimulus

For the females:

c) Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model session	4		
Model optimum	5	13.779	2.02-04***
	Df	Chisq	Pr(>Chisq)

Model trial	4		
Model optimum	5	5.549	0.018 *

Between optimum model and baseline (χ^2_1 36.25, N=9, P = 8.464e-07 ***).

d) Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	5		
Model age	6	3.011	0.083
Model rank	7	2.919	0.087
Model rule	8	1.890	0.169

Result of the anovas, only in females, between models containing variables having significant effect for the log 10 of the number of taps on a successful trial. a) Variables having a significant effect on the models: session and trial. The model optimum contains all variables having a significant effect on the model. b) Variables having no significant effect on the models (age, sex and rule).

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S21

Log10 of Number of taps when trial was failed

For the females:

Predictor	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	0.951	0.034	27.684	0.000
Rule (reversed)	-0.030	0.022	-1.370	0.171
Rank (low)	-0.043	0.022	-2.004	0.045
Age	-0.008	0.003	-2.595	0.010
Trial	-0.002	0.001	-2.384	0.017*
Session	-0.020	0.004	-5.181	0.000***

Results of LMMs, only in females, for the number taps when a trial was failed. Explanatory factors were divided in 2 categories of determinants: individual characteristics (age and rank) and experimental determinants (acquisition rule or reversed rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method. The variables in bold had a significant effect on the models.

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S22

Response latency when success

Males and females:

a) Variables having a significant effect on the model:

	Df	Chisq	Pr(>Chisq)
--	----	-------	------------

Model session	4		
Model optimum	5	7.212	0.007***

	Df	Chisq	Pr(>Chisq)
Model rule	4		
Model optimum	5	36.070	1.906e-09***

Between optimum model and baseline ($\chi^2_1 = 38.925$, N=19, P = 3.53-09).

b) Variables having no significant effect on the model:

	Df	Chisq	Pr(>Chisq)
Model optimum	5		
Model sex	6	3.422	0.064
Model trial	7	0.092	0.761
Model age	8	0.085	0.771

Result of the anovas between models containing variables having significant effect for response latency successful trial. a) Variables having a significant effect on the models: rule and session. The model optimum contains all variables having a significant effect on the model. b) Variables having no significant effect on the models (age, trial and sex).

* p < 0.05, ** p < 0.01, *** p < 0.001

Table S23

Log of Response latency on a successful trial

Predictor	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	7.738	0.346	25.704	4.34e-18
Rule (reverse)	0.213	0.037	5.701	1.81e-08***
Sex (female)	0.411	0.257	1.452	0.121
Age	-0.007	0.028	-0.290	0.774
Trial	0.000	0.002	-0.343	0.732
session	0.027	0.010	2.594	0.009**

Results of LMMs for the log of response latency on a correct trial. Explanatory factors were divided in individual (sex and age=) and experimental determinants (rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method. The variable in bold had a significant effect on the models.

Table S24

Log of Response latency on a successful trial

For the females:

	Df	Chisq	Pr(>Chisq)
Model optimum	3		
Model rule	4	7.223	0.007**
Model rank	5	0.025	0.873

Model age	6	0.956	0.328
Model trial	7	0.124	0.725
Model session	8	0.006	0.937

Result of the anovas, only in females, between models containing variables having significant effect for response latency successful trial. The model optimum contains all variables having a significant effect on the model. The variable rule only had a significant main effect on the models.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table S25

Log of Response latency on a successful trial

For the females:

Predictor	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	8.709	0.457	19.065	0.000
Rule				
(reverse)	0.161	0.065	2.456	0.014*
Age	-0.045	0.044	-1.011	0.325
Rank (low)	-0.168	0.398	-0.421	0.687
Trial	-0.001	0.002	-0.351	0.725
session	-0.001	0.014	-0.075	0.941

Results of LMMs, only in females, for the log of response latency on a correct trial. Explanatory factors were divided in individual (age and rank) and experimental determinants (rule, trial and session). All full models included the individual ID as random factor. The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable), Standard Error, t-value and p-value using maximum likelihood method. The variable in bold had a significant effect on the models.