

Supplementary materials

The supplementary materials file includes a description of the touchscreen training of the subjects and supplementary results.

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 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 2000 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. 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. Five subjects abandoned this training phase as they stayed at distance from the screen or gave birth in the meantime.

Supplementary results

Executive function Task:

TEMPORAL REPEATABILITY

Table S1

Results of GLMMs for the Accuracy in the Executive function task. Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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. None of the variables had a significant effect on the models.

<i>Executive function accuracy</i>				
Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	0.869	0.065	13.313	0.000
Sex male	0.033	0.039	0.853	0.406
Age	-0.007	0.005	-1.480	0.158
Rank high	0.022	0.068	0.339	0.739
Rank medium	0.051	0.070	0.718	0.483
Session	0.016	0.013	1.221	0.225
Time point	0.021	0.021	1.024	0.306

The Distraction task:

CONTENT VALIDITY

Table S2

Results of LMMs for the log transformation of the response latency in the Distraction task. Confounding factors were divided in individual (sex, age, rank and experience with picture) and experimental determinants (session and time point). 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 stimulus, age, trial and time point had a significant effect on the models.

log(response latency) on a trial

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	8.223	0.213	38.526	0.000
Stimulus picture	0.112	0.035	3.189	0.001
Picture Object vs face	0.018	0.025	0.753	0.452
Picture Threat vs neutral	-0.058	0.043	-1.350	0.177
Sex male	0.120	0.150	0.801	0.436
Age	0.043	0.018	2.296	0.035
Rank high	-0.029	0.224	-0.130	0.898
Rank medium	-0.368	0.250	-1.472	0.162
Experience picture	-0.084	0.097	-0.862	0.388
Trial	0.000	0.002	0.069	0.944
Session	-0.035	0.017	-2.20	0.027
Time point	-0.534	0.032	-16.877	0.000

Note. Number of subjects = 21

Likelihood-ratio test comparing the best fitted model (with session, time point and age as explanatory variables) with the null model : $\chi^2_4 = 296.02$, $p < 0.0001$.

The subjects had a longer response latency as they get older ($\chi^2_1 = 9.086$, $p < 0.01$), and their response latency were shorter as session ($\chi^2_1 = 4.798$, $p < 0.05$) and time point ($\chi^2_4 = 276.165$, $p < 0.0001$) increased.

TEMPORAL REPEATABILITY

Table S3

Results of LMMs for the Distraction control score (the Distraction task). Confounding factors were divided in individual (sex, age, rank and experience with picture) and experimental determinants (session and time point). 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. Only the variables in bold sex, session and time point had a significant effect on the models.

Distraction control score

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	-500.347	903.952	-0.554	0.579
Sex male	-1411.504	631.269	-2.236	0.041
Age	-111.284	104.125	-1.065	0.304
Rank high	-838.105	935.795	-0.896	0.385

Rank medium	528.053	995.247	0.531	0.603
Experience with pictures	398.939	864.463	0.461	0.651
Trial	6.374	9.807	0.649	0.517
Session	455.514	124.249	3.666	0.0003
Time point	2019.521	205.8753	9.815	0.000
Type picture Object	-118.94	245.685	-0.484	0.628
Type picture Threat	66.453	249.686	0.266	0.790

CONTENT VALIDITY

Go/No-go task:

Table S4

Results of GLMMs for the success in the Go/No-go task. Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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 type of stimulus (Go or No-go) and session had a significant effect on the models.

<i>Success on a trial</i>				
Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	7.431	0.671	11.072	0.000
Stimulus No-Go	-7.098	0.413	-17.196	0.000
Sex female	-0.300	0.200	-1.5000	0.134
Age	-0.004	0.037	-0.111	0.911
Rank high	-0.669	0.513	-1.285	0.199
Rank medium	-0.902	0.538	-1.675	0.094
Trial	0.001	0.004	0.173	0.862
Session	0.081	0.033	2.456	0.014
Time point	0.091	0.093	0.972	0.331

Note. Number of subjects 20

Likelihood-ratio test comparing the best fitted model (with type of stimulus and session as explanatory variables) with the null model: $\chi^2_2 = 3335.6$, $p < 0.0001$.

The success on a trial was higher as the number of the session increased: $\chi^2_1 = 6.172$, $p < 0.05$.

Table S5

Results of LMMs for the log transformation of the response latency in the Go/No-go task. Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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. Only the variable in bold stimulus had a significant effect on the models.

<i>log(response latency) on a trial</i>				
Predictor	Estimate	Std. Error	z-value	p-value
(Intercept)	7.638	0.160	47.800	0.000
Stimulus	0.509	0.020	24.969	0.000
No-Go				
Sex	-0.041	0.042	-0.967	0.334
female				
Age	0.006	0.012	0.555	0.579
Rank high	-0.290	0.165	-1.760	0.096
Rank	-0.249	0.175	-1.427	0.172
medium				
Trial	-0.001	0.001	-0.969	0.332
Session	0.010	0.006	1.640	0.101
Time	0.001	0.018	0.068	0.946
point				

Note. Number of subjects 20

Likelihood-ratio test comparing the best fitted model (with type of stimulus as explanatory variables) with the null model: $\chi^2_1 = 600.73$, $p < 0.001$.

TEMPORAL REPEATABILITY

Table S6

Results of LMMs for the Action Control Score (Go/No-go). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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. None of the variable had a significant effect on the models.

<i>Action control score</i>				
Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	47.742	13.653	3.497	0.001
Sex male	-10.487	9.604	-1.092	0.292
Age	0.744	1.061	0.701	0.494
Rank high	-5.107	13.361	-0.382	0.701

Rank				
medium	-13.939	14.607	-0.954	0.355
Session	4.631	2.851	1.646	0.103
Time point	2.983	4.370	0.631	0.523

Reversal learning task:

CONTENT VALIDITY

Table S7

Results of GLMMs for the success in the Reversal learning task. Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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 variables in bold rule, trial and session had a significant effect on the models.

Success on a trial				
Predictor	Estimate	Std. Error	z value	p-value
(Intercept)	0.797	0.272	2.885	0.004
Ruverse rule	-0.099	0.069	-1.437	0.150
Sex female	-0.185	0.157	-1.183	0.237
Age	-0.025	0.016	-1.607	0.108
Rank high	0.030	0.230	0.130	0.897
Rank medium	0.006	0.244	0.025	0.98
Trial	0.005	0.002	2.047	0.041
Session	0.056	0.017	3.377	0.001
Time point	-0.088	0.072	-1.233	0.218

Note. Number of subjects 19

Likelihood-ratio test comparing the best fitted model with the null model: $\chi^2_4 = 27.74$, $p < 0.001$.

The success on a trial was higher as the trials ($\chi^2_1 = 4.101$, $p < 0.05$) and session increased ($\chi^2_1 = 11.687$, $p < 0.05$).

TEMPORAL REPEATABILITY

Table S8

Results of GLMMs for the Rule Control Score (Reversal learning task). Confounding factors were divided in individual (sex, age, rank) and experimental determinants (session and time point). The Estimates (representing the change in the dependent variable relative to the

baseline category of each predictor variable), z-value and p-value using maximum likelihood method. None of the variable had a significant effect on the model.

Rule control score

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	26.882	98.731	0.272	0.789
Sex male	-109.509	65.719	-1.666	0.118
Age	6.471	8.011	0.808	0.4323
Rank high	-2.566	111.981	-0.023	0.982
Rank medium	22.372	117.197	0.191	0.851
Time point	-2.001	13.721	-0.146	0.887

CONTEXTUAL REPEATABILITY

Table S9

Contextual unadjusted repeatability estimates of the scores of executive function and inhibitory control. Executive function accuracy (Executive function), Distraction control score (Distraction task), Action control score (Go/No-go) and Rule control score (Reversal Learning) are represented

Contextual R for the scores	Executive function accuracy	Distraction control	Action control	Rule control
Executive function accuracy	1	-	-	-
Distraction control	✓ 0.148 (p = 1.57e-04)***	1	-	-
Action control	✓ 0.121 (p = 0.001)***	✓ 0.166 (p = 2.69e-05)***	1	-
Rule control	✓ 0.102 (p = 0.0378)*	✓ 0.212 (p = 9.46e-04) ***	✓ 0.138 (p = 0.012)*	1

✓ Indicates that the individual's performances are significantly repeatable between tasks.
* p < 0.05, ** p < 0.01, *** p < 0.001

Table S10

Results of LMMs for the Executive function task (Executive function accuracy) and the Distraction task (Distraction Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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), t-value and p-

value using maximum likelihood method. The variables in bold session and time point had a significant effect on the models.

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	-0.030	0.151	-0.195	0.845
Task	-0.044	0.055	-0.804	0.422
Modified Stroop				
Sex male	-0.114	0.085	-1.331	0.202
Age	-0.016	0.011	-1.522	0.148
Rank high	-0.044	0.147	-0.300	0.769
Rank medium	0.130	0.154	0.854	0.410
Session	0.071	0.034	2.123	0.035
Time point	0.227	0.055	4.116	0.000

Table S11

Results of LMMs for the Distraction task (Distraction control scores) and the Go/No-go task (Action Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). The Estimates (representing the change in the dependent variable relative to the baseline category of each predictor variable t-value and p-value using maximum likelihood method. The variables in bold session and time point had a significant effect on the models.

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	-0.121	0.260	-0.465	0.642
Task	0.012	0.096	0.128	0.898
Go/No-go				
Sex male	-0.381	0.162	-2.338	0.032
Age	0.007	0.020	0.320	0.752
Rank high	-0.131	0.229	-0.574	0.567
Rank medium	-0.142	0.258	-0.551	0.588
Session	0.126	0.058	2.160	0.032
Time point	0.268	0.096	2.809	0.006

Table S12

Results of LMMs for the Go/No-go (Action control scores) and the Reversal learning task (Rule Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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 t-value and p-value using maximum likelihood method. Only the variable in bold sex had a significant effect on the model (when comparing with the full model).

Predictor	Estimate	Std.Error	t-value	p-value
(Intercept)	-0.225	0.367	-0.613	0.541
Task	0.183	0.219	0.838	0.404
Reversal learning				
Sex male	-0.444	0.218	-2.034	0.057
Age	0.030	0.025	1.230	0.221
Rank high	-0.136	0.304	-0.447	0.656
Rank medium	-0.387	0.346	-1.152	0.265
Session	0.163	0.112	1.457	0.148
Time point	0.122	0.162	0.751	0.454

Table S13

Results of LMMs for the Distraction task (Distraction control scores) and the Reversal learning task (Rule Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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 sex and time point had a significant effect on the models.

Predictor	Estimate	Std. Error	t-value	p-value
(Intercept)	-0.094	0.243	-0.389	0.698
Task	0.114	0.131	0.872	0.385
Reversal learning				
Sex male	-0.416	0.133	-3.140	0.006
Age	0.006	0.016	0.396	0.693
Rank high	-0.145	0.224	-0.648	0.526
Rank medium	0.050	0.234	0.212	0.8345
Session	0.099	0.065	1.530	0.128
Time point	0.309	0.095	3.266	0.001

Table S14

Results of LMMs for the Executive function task (Executive function Accuracy) and the Go/No-go task (Action Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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), t-value and p-value using maximum likelihood method. None of the variables had a significant effect on the models.

Predictor	Value	Std.Error	t-value	p-value
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(Intercept)	0.030	0.261	0.115	0.909
Task	-0.028	0.095	-0.300	0.764
Go/No-go				
Sex male	-0.098	0.163	-0.599	0.557
Age	0.004	0.019	0.217	0.831
Rank high	-0.255	0.230	-1.107	0.299
Rank medium	-0.321	0.260	-1.235	0.234
Session	0.102	0.057	1.788	0.075
Time point	0.094	0.093	1.016	0.311

Table S15

Results of LMMs for the Executive function task (Executive function Accuracy) and the Reversal learning task (Rule Control Score). Confounding factors were divided in individual (sex, age and rank) and experimental determinants (session and time point). 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), t-value and p-value using maximum likelihood method. None of the variables had a significant effect on the model.

Predictor	Estimate	Std.Error	t-value	p-value
(Intercept)	-0.067	0.245	-0.270	0.788
Task	0.033	0.130	0.258	0.797
Reversal learning				
Sex male	-0.060	0.134	-0.450	0.658
Age	-0.005	0.016	-0.316	0.753
Rank high	0.014	0.231	0.00	0.953
Rank medium	0.085	0.242	0.352	0.729
Session	0.048	0.063	0.761	0.448
Time point	0.077	0.092	0.838	0.403