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Supplementary Information for
Space and rank: Infants expect agents in higher position to be socially dominant

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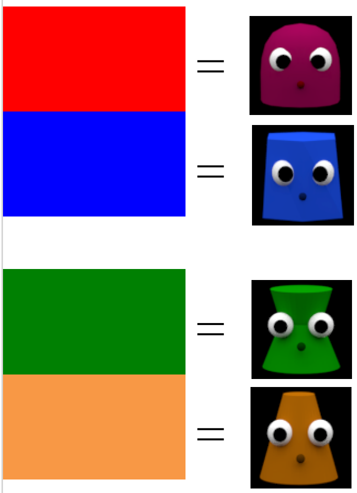
This PDF file includes:

<u>**Stimuli pattern**</u>

Pattern		Left*	Right*	
	(*From the participant's view; Applicable only to Experiment 1)			
1	Wins in 1st test	high	low	
2		high	low	Wins in 1st test
3	Wins in 1st test	low	high	
4		low	high	Wins in 1st test
5		high	low	Wins in 1st test
6	Wins in 1st test	high	low	
7		low	high	Wins in 1st test
8	Wins in 1st test	low	high	
9	Wins in 1st test	high	low	
10		high	low	Wins in 1st test
11	Wins in 1st test	low	high	
12		low	high	Wins in 1st test
13		high	low	Wins in 1st test
14	Wins in 1st test	high	low	
15		low	high	Wins in 1st test
16	Wins in 1st test	low	high	



→ Agent that appears in the first trial in the Single agent collection.

<u>**Participants**</u>

Experiment 1

Twelve additional infants were tested but were excluded from the final sample for these reasons: they were too fussy to participate in the animation (n = 6); we had to end the experiment before completion (n = 1); the infants' eyes were out of the camera field so that the coding could not take place (n = 2); the infants did not watch the screen at the point when the agents' movement ended – the onset of the target gaze duration in the test (n = 2); and finally, an experimental error excluded one infant for whom the online coder ended the test phase before infant looked out of the monitor for two seconds (n = 1).

Experiment 2

Seven additional infants were tested but were excluded from the final sample because: some were fussy and unable to watch the animation (n = 3), the experiment was interrupted while caregivers adjusted infant's position (n = 1), the caregiver elicited eye contact with the infant in the test phases (n = 1), the sibling of the infant talked to the infant (n = 1), or because of an experimental error in which the experimenter the caregiver move the infant back into the camera field (n = 1).

Coding and analysis

Experiment 1

Experimenter B coded infants' looking behaviour during the test phase online and sent a signal to experimenter A to stop the test phase after infants had looked away from the monitor for > 2 seconds, using a custom program on Visual Basic 2017 that detects key press and notifies if two consecutive seconds have elapsed. Experimenter B did not watch the videos, so he was unaware of which agent in the test phase was in a high or low position. Then, we exported the recordings that contained infants' gaze points (Tobii Studio; 30 fps), and we used ELAN to code them frame by frame as primary data because offline coding is considered to be more accurate than online coding. Since experimenter B conducted online coding, offline coding was undertaken by experimenter A. It is noteworthy that, although experimenter A controlled the presentation of stimuli during testing, he was unaware of which agents occupied the high and low positions in the SPP phase, when he conducted offline coding. This was because (1) offline coding was conducted after the completion of data collection for experiment 1, and consequently, experimenter A is unlikely to have remembered which stimuli pattern was assigned to a specific infant; and (2) he coded only infants' looking behaviours in the test phases and was therefore unaware of the contexts of the SPP or SAC phase. Identical to the online coding, experimenter A coded whether infants looked towards the screen after the animation froze, and calculated the duration until infants looked away from the screen for >2 s, or after 60 s had elapsed [1]. We intended to analyse the offline-coded data. Accordingly, to assess the reliability of the offline-coded data, an additional experimenter (i.e. experimenter C) who was uninvolved in the experiment and consequently unaware of the experimental contexts coded all the test trials. The intraclass correlation (ICC) between the two raters was 0.989, 95% CI [0.978, 0.994]. Gaze duration in the SPP and SAC phases were calculated by Tobii Studio. For the SPP phases, we created two rectangular areas of interest (AOIs; 150 × 150 pixels; [2]) around the agents to specify the infant's gazing behaviour. For the SAC phases, we used infants' gazing behaviour data toward the whole screen. Gaze data were calculated by the Raw Data Fixation Filter by applying Gap fill-in (interpolation; Max gap length for 75 ms; [3]) and Noise reduction (moving average; Windows size for 3 samples; [4]) functions.

Experiment 2

The intraclass correlation (ICC) between the two coders was 0.983, 95% CI [0.966, 0.991].

Experiment 3 (Replication of Experiment 2)

To confirm that the previous findings were not limited to the experimental circumstance (e.g., the built-in camera of the eye tracking system for capturing infants' looking behaviours, size of the monitor), we conducted Experiment 3 with different materials such as a different booth, a differently sized screen, the manner of handling infants, and lighting. The findings revealed that infants' looking behaviours towards the agents before test phases did not influence the inference of social dominance, and due to the equipment availability of Experiment 3, we did not use the eye tracking system to collect gaze data in SPP and SAC phases. We focused on whether the infants were looking at the entire screen in test phases.

(a) Method

(i) Participants

Eighteen 12-16-month-old infants participated in Experiment 3 (11 girls; Mage = 446 days, SD = 45.81, range = 370-509 days). Six additional infants were tested but were excluded from the final sample because they were fidgety; they did not make it to the animation (n = 4) because the experiment was interrupted as the caregivers adjusted the infant's position (n = 1) and elicited eye contact with the infant (n = 1) in the test phases.

(ii) Setup

Experiment 3 was conducted in another open booth (195×315×150 cm) which was set up in the same room with Experiments 1 and 2, but lights were much darker than earlier. Infants were seated on their caregivers' laps, approximately 120 cm from a 55-inch (121.54 × 68.45 cm) SONY BRAVIA X8500E television on which the experimental visual and audio stimulus were presented. To increase the appearance of a real situation, we set the television on the carpeted floor and had the caregivers sit on the floor throughout. Four video cameras recorded the experiment: three hidden cameras captured whether infants were looking at the screen from the top, right, and left sides of the television; and one camera captured the stimuli from the back of the participants. The recordings were synchronised through a video mixer (Roland). Outside the booth, two experimenters controlled the stimuli presentation using Microsoft PowerPoint 16.16 and coded infants' gaze duration data online through a video screen (23-inch TFT, 1920 × 1080 pixels). The coding methods were identical to the previous experiments.

(iii) Stimuli and procedure

Stimuli and procedures were identical to Experiment 2, except that the calibration was conducted by a movie which presented 6 diamonds that covered each side of the screen (Fig. 1 in the main text). Infants' gazes during the calibration provided the criterion for judgement of whether they looked inside or outside the screen.

(iv) Coding and analysis

Coding and analysis were identical to Experiment 2 [5–8], except that (1) the recordings for offline coding had a frame rate of 60 because we used the original video clips of the video mixer, and (2) we did not investigate infants' gazing behaviour in SPP and SAC phases because previous experiments have shown that these have no differentiating effect on gaze duration. The intraclass correlation (ICC) between the two coders was 0.995, 95% CI [0.991, 0.998].

(b) Results and discussion

Infants looked at the screen for M = 14.09 s (SD = 10.492) after the video froze at the point when the higher agent had taken away the goal object, and for M =

18.11 s (SD = 11.827) when the lower agent had taken it away (Fig. 2 in the main text). As predicted, the results of a Paired Sample T-test and the GLMM indicated a significant effect the test type ($t = 2.09$, $df = 17$, $p = 0.026$, one-tailed, Cohen's $d = 0.492$; $\beta = 0.458$, $df = 17$, $t = 2.09$, $p = 0.026$, one-tailed; *SI Table S5)*.

Experiment 3 confirmed the results of Experiment 2, demonstrating that infants looked at the screen longer when they saw the Violation-of-Expectation scenario.

Results of the generalised linear mixed models (GLMMs) for Experiments 1, 2, and 3

Table S1. Estimated regression parameters, standard errors (SE), degrees of freedom (df), and t- and p-values for the GLMMs of Experiment 1

Fixed effects

	Estimate	SE	df	t-value	P-value
(Intercept)	1.448	3.835	13.017	0.378	0.712
Test type	0.593	0.193	17.000	3.077	0.007
Test order	-0.236	0.589	13.000	-0.400	0.695
Stimuli pattern	0.024	0.070	13.000	0.340	0.740
Age	0.001	0.008	13.000	0.088	0.931
Gender	-0.036	0.661	13.000	-0.054	0.957

Random effects

Groups	Name	Variance	SD
ID	(Intercept)	1.153	1.074
Residual		0.335	0.579
Number of observations: 36, groups: ID, 18			

Table S2. Estimated regression parameters, standard errors (SE), degrees of freedom (df), and t- and p-values for the GLMMs of Experiment 1

Fixed effects

	Estimate	SE	df	t-value	P-value
(Intercept)	1.820	0.291	17.456	6.259	0.001
Test type	0.594	0.193	17.000	3.077	0.007

SPP	-0.445	0.504	14.000	-0.883	0.392
SAC	-0.455	0.675	14.000	-0.674	0.511
SPP × SAC	2.631	8.466	14.000	0.311	0.761

Random effects

Groups	**Name**	**Variance**	**SD**
ID	(Intercept)	0.944	0.972
Residual		0.335	0.579
Number of observations: 36, groups: ID, 18			

Table S3. Estimated regression parameters, standard errors (SE), degrees of freedom (df), and t- and p-values for the GLMMs of Experiment 2

Fixed effects

	Estimate	**SE**	**df**	**t-value**	**P-value**
(Intercept)	2.652	2.099	13.043	1.263	0.229
Test type	0.554	0.171	17.000	3.245	0.005
Test order	0.112	0.395	13.000	0.283	0.782
Stimuli pattern	0.031	0.044	13.000	0.717	0.486
Age	-0.002	0.004	13.000	-0.429	0.675
Gender	-0.089	0.371	13.000	-0.241	0.814

Random effects

Groups	**Name**	**Variance**	**SD**
ID	(Intercept)	0.476	0.690
Residual		0.263	0.512
Number of observations: 36, groups: ID, 18			

Table S4. Estimated regression parameters, standard errors (SE), degrees of freedom (df), and t- and p-values for the GLMMs of Experiment 2

Fixed effects exp2

	Estimate	**SE**	**df**	**t-value**	**P-value**
(Intercept)	1.919	0.323	16.107	5.937	0.001
Test type	0.554	0.171	17.000	3.245	0.005
SPP	0.312	0.364	14.000	0.858	0.405

SAC	-0.054	6.776	14.000	-0.008	0.994
SPP × SAC	3.600	9.085	14.000	0.396	0.698
Random effects					
Groups	**Name**	**Variance**	**SD**		
ID	(Intercept)	0.410	0.641		
Residual		0.263	0.512		
Number of observations: 36, groups: ID, 18					

Table S5. Estimated regression parameters, standard errors (SE), degrees of freedom (df), and t- and p-values for the GLMMs of Experiment 3

Fixed effects					
	Estimate	**SE**	**df**	**t-value**	**P-value**
(Intercept)	6.632	2.611	13.046	2.540	0.025
Test type	0.458	0.219	17.000	2.089	0.052
Test order	0.308	0.568	13.000	0.542	0.597
Stimuli pattern	-0.020	0.046	13.000	-0.428	0.676
Age	-0.009	0.006	13.000	-1.649	0.123
Gender	-0.438	0.499	13.000	-0.877	0.397
Random effects					
Groups	**Name**	**Variance**	**SD**		
ID	(Intercept)	0.707	0.841		
Residual		0.433	0.658		
Number of observations: 36, groups: ID, 18					

Meta-analytic results for differences in gaze durations in the test phases of all experiments

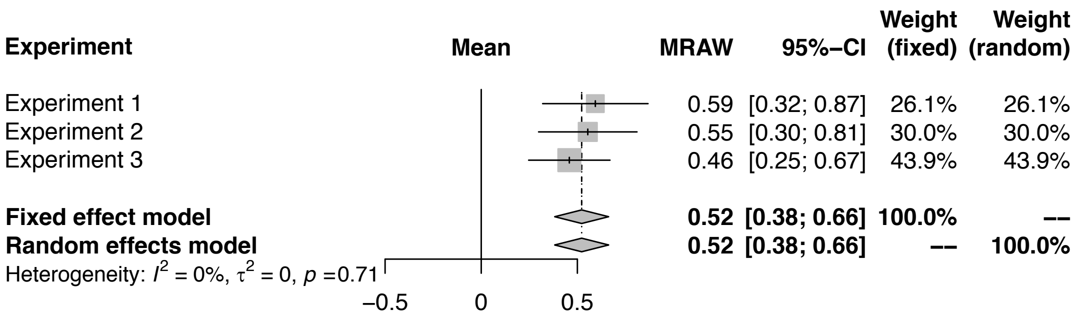


Figure S1. Meta-analytic results for differences in gaze durations for the test phases of Experiments 1, 2, and 3. The figure presents the overall mean for difference in gaze durations between the two types of tests (i.e. by subtracting gaze durations in the test phase in which the high-position agent won from the gaze durations in the test phase in which the low-position agent won), which was calculated from data of all experiments using the inverse variance method for pooling[1]. Fixed- and random-effects meta-analysis of single means was undertaken to calculate an overall mean. MRAW presents untransformed means. I^2 presents the proportion of observed variance that reflects real differences in effect size [9]. τ^2 presents the dispersion of true effect sizes between studies in terms of the scale of the effect size. The meta-analysis was found to lack heterogeneity [10].

Analysis of variance (ANOVA) of gaze durations in the test phases of all experiments

We merged the data of all the three experiments and confirmed that infants' gaze durations in test phases were affected by the test type (i.e. whether the high/low-position agent gained the reward object) but not the experiment (i.e. experiment 1, 2, or 3; Tables S6 and S7), experimental circumstances (e.g. whether the experiment was conducted using an eye-tracker; Tables S8 and S9), or type of stand that was used to elevate agents to different spatial positions (i.e. podium vs. double-decker stand; Tables S10 and S11). Two-way ANOVAs of gaze durations with a within-subjects factor, namely, test type (high vs. low-position agent prevailed), and a specific between-

[1] We conducted this meta-analysis in R (version 3.5.0) using the metamean function of the meta package [6,11]. All the reported p-values are two-tailed.

subjects factor (i.e. experiment, experimental circumstance, or type of stand) revealed significant main effects for test type (ps < .001), but the other main and interaction effects (ps > .21) were not significant.

Table S6. Within-subjects effects of test type (i.e. high- or low-position agent won the resource in the test phase) and the interaction between test type and experiment (i.e. experiment 1, 2, or 3) on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Test type	7.736	1	7.736	22.528	< .001	0.305	0.306	0.068
Test type × Experiment	0.087	2	0.044	0.127	0.881	0.003	0.005	0.000
Residual	17.514	51	0.343					

Note. SS = Type III Sum of Squares

Table S7. Between-subjects effects of experiment on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Experiment	2.570	2	1.285	0.800	0.455	0.030	0.030	0.000
Residual	81.93	51	1.606					

Note. SS = Type III Sum of Squares

Table S8. Within-subjects effects of test type (i.e. high- or low-position agent won the resource in the test phase) and the interaction between test type and experimental circumstance (e.g. whether the experiment was conducted using an eye-tracker) on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Test type	6.390	1	6.390	18.965	< .001	0.266	0.267	0.055
Test type × Experimental circumstance	0.080	1	0.080	0.238	0.627	0.003	0.005	0.000
Residual	17.521	52	0.337					

Note. SS = Type III Sum of Squares

Table S9. Between-subjects effects of experimental circumstance on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Experimental circumstance	0.915	1	0.915	0.569	0.454	0.011	0.011	0.000
Residual	83.585	52	1.607					

Note. SS = Type III Sum of Squares

Table S10. Within-subjects effects of test type (i.e. high- or low-position agent won the resource in the test phase) and the interaction between test type and type of stand that was used to elevate agents to different spatial positions (i.e. podium vs. double-decker stand) on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Test type	7.256	1	7.256	21.491	< .001	0.292	0.292	0.064
Test type × Stand type	0.046	1	0.046	0.135	0.714	0.002	0.003	0.000
Residual	17.556	52	0.338					

Note. SS = Type III Sum of Squares

Table S11. Between-subjects effects of stand type on natural log-transformed gaze durations across all experiments

	SS	df	Mean Square	F	p	η^2	η^2_p	ω^2
Stand type	2.535	1	2.535	1.608	0.21	0.030	0.030	0.011
Residual	81.965	52	1.576					

Note. SS = Type III Sum of Squares

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