Supplementary Online Materials

Chimpanzee cooperation is fast, and independent from self-control

Subjects

We tested 40 semi-free ranging chimpanzees (21 males, 19 females) living in Tchimpounga Chimpanzee Sanctuary in Pointe-Noire, Republic of Congo (see Table 1). Animal husbandry and care practices at the sanctuary comply with the Pan-African Sanctuary Alliance (PASA) guidelines. Apes in African sanctuaries are born in the wild and typically enter the sanctuary after being confiscated at an early age (~2-3 years old) as a result of the trade in wildlife for pets and bushmeat. Previous work indicates that sanctuary apes are psychologically healthy relative to other captive populations [1, 2]. All apes were socially housed, and the majority free-ranged in large tracts of tropical forest during the day (5-40 hectares across groups). In the evening, apes slept in indoor dormitories (12 m^2-160 m^2). Apes were tested individually in these familiar dormitory buildings. Following testing, most apes were released back to their larger social groups outside. Apes had *ad libitum* access to water and were never food-deprived for testing. In addition to the food in the forest, they were fed a variety of fruits, vegetables, and species-appropriate foods. All tests were voluntary: if subjects stopped participating, the test was stopped.

General Procedure

Apes completed a decision-making battery comprising a total of 11 tasks administered across 7 days of testing, with all individuals completing the tasks in the same order across days. The current paper focuses on a subset of six tasks examining social decision-making and impulsivity; the remaining tasks addressed aspects of reward-based decision-making and memory unrelated to the current hypotheses. The order of the tasks across days was designed to ensure that each day of testing took approximately 30 minutes per subject, such that shorter tasks were grouped together on the same day. All apes completed all tests, with two exceptions: one female chimpanzee would not participate in the donation task and one male chimpanzee would not participate in the go/no-go task; these individuals were excluded from analyses involving these data. In the current study, we analyzed a subset of 6 tasks:

1) altruistic donation task (administered second on day 5)
2) instrumental helping task (administered first on day 4)
3) punishment task (administered second on day 6)
4) intertemporal choice task (only task administered on day 2)
5) go/no-go task (administered first on day 6)
6) social responsivity task (administered first on day 1)

During testing, the apes sat in a room in their dormitory building. For the majority of the tasks, the ape and human sat across from each other at a table (80 cm wide, 40 cm deep, 50 cm tall) with a sliding top, separated by bars. The experimenter placed relevant options on the tabletop within view of the ape. In tasks where the chimpanzee had to make a choice, the experimenter then pushed the table forward, so chimpanzees could indicate their choice by pointing or touching one option, protruding their fingers through the bars. The experimenter always looked down or along the midline of the table (e.g., not at the options) in order to avoid potential social cueing. All studies were videotaped (from one or two angles, depending on the study).

Name	Sex	Age (yrs)	Donation	Helping	Punishment
Akim	M	21	0.45	0.50	0.00
Chinoc	M	21	0.45	0.00	0.00
Christophe	M	22	**0.90**	0.00	0.00
Elikia	M	24	0.60	1.00	0.30
Grand Maitre[1]	M	25	0.50	0.00	0.00
Imphondo	F	18	0.50	0.60	0.00
Isabelle	F	7	0.45	0.10	0.00
Kaoka	M	6.5	0.70	0.10	0.80
Kefan	M	12	0.65	0.90	0.00
Kiki	F	22	0.65	1.00	0.10
Kimenga	M	9.5	0.45	0.60	0.10
Koungoulou[3]	M	23	0.55	0.00	0.20
Kudia	F	7	**0.75**	0.00	0.40
Loufoua	M	11	0.45	0.20	0.00
Louise	F	8.5	0.70	0.60	0.00
LowLow	F	19	0.50	1.00	0.00
Lucie	F	22	0.60	0.40	0.00
Lusingou	M	7	0.35	0.20	0.90
M'Vouti	F	10.5	0.60	0.80	0.60
Mabwesso	M	19	0.50	1.00	0.20
Mama[2]	F	24	-	0.00	1.00
Manisa	F	6	0.50	0.70	0.50
Maya	M	18	**0.75**	1.00	0.00
N'Gao	F	10.5	0.60	0.90	0.00
N'Golo	M	21	0.50	1.00	0.00
N'Goro	F	7	0.55	1.00	0.00
N'Guado	M	20	0.30	0.70	0.30
N'tsere	M	17	0.55	0.40	0.00
Niari	M	20	0.50	1.00	0.30
Pembele	F	20	0.40	1.00	0.00
Podive	M	7	0.50	0.00	0.50
Pongou	F	6	0.65	0.40	0.20
Ramsey	F	16	**0.80**	1.00	0.00
Stephanie	F	23	0.50	0.30	0.10
Tambikissa	F	8	0.55	0.30	0.00
Tchivgna	F	8	0.40	1.00	0.50
Ulemvouka	F	12	0.60	0.90	0.80
Ulengue	M	8	0.70	0.80	0.00
Wolo	M	15	0.80	0.90	0.00
Yoko	M	16	0.60	1.00	0.00

Table S1: Subjects in decision battery and mean performance in prosocial tasks. In the donation task, means indicate subject's choice for a prosocial option (out of 20 trials); bolded subjects chose the prosocial option above chance (15/20 in binary test, $p < 0.05$). In the helping task, means indicate subject's propensity to pick up and give the object in their room for which the experimenter was reaching (out of 10 trials). In the punishment task, means indicate subject's propensity to collapse the table on a culpable thief (out of 10 trials). [1]Chimpanzee did not complete donation task. [2]Chimpanzee did not complete go-no-go task. [3]Chimpanzee did not approach during social responsivity task.

Overview of Statistical Analyses

We analyzed data in R version 3.4.1 [3]. To analyze trial-by-trial responses [4], we implemented generalized linear mixed models (GLMM) using the *glmer* function, or linear mixed models using the *lmer* function, both from the lme4 software package [5]. Random *subject* intercepts were included to account for repeated trials within subjects. To examine the relationship between individual variation in mean responses and mean latencies across some tasks, we used linear regressions implemented with the *lm* function in the lme4 package. Across analyses, we compared the fit of different models using likelihood ratio tests [6]. Graphs showing predicted effects and 95% confidence intervals (CIs) from these models were calculated using the effects package in R [7]. We calculated 95% Cis for descriptive statistics using the t distribution, and graphs depicting 95% CIs as error bars were calculated using within-subject normalized Cis using the methods from [8], implemented using the RMisc package [9].

For linear mixed models implemented with *lmer*, models were refit using maximum likelihood for model comparisons using likelihood ratio test [10], and parameter significance was calculated using the lmerTest package [11]. To compute pairwise comparisons predictions from the linear models (e.g., predicted marginal means), we used the lsmeans package [12].

Finally, to provide positive support for null findings, we used Bayes Factor analysis [13], implemented in the BayesMed package [14]. Here, we used the *jzs_cor* function in the BayesMed software in R [14]. The Bayesian hypothesis test for correlation allows a quantification of the null hypothesis that the correlation between pairs of variables is zero. We used a two-sided alternative hypothesis that the population correlation does not equal 0, using a Jeffreys-Zellner-Siow prior set-up. We report BF_{01}, which quantifies evidence for the null hypothesis relative to the alternative hypothesis (where $BF_{01} = 1/BF_{10}$; see main text for Bayes Factors for each task).

Resource Donation Task

This task assessed the chimpanzees' preferences when choosing between two options: a *selfish option* that provided the chimpanzee with one piece of food but provided nothing to the human partner; and a *prosocial option* that provided both the chimpanzee and the partner with food, following the basic procedure in Silk et al. [15]. Here, the recipient actively indicated their desire for the prosocial option, following previous research indicating that both chimpanzees [16] and young children [17] use such goal cues when making decisions about whether to share with others (see Figure S1 and Movie S1).

Procedure

Experimenter 1 (E1) sat to one side of the table and distributed food rewards that the ape could choose between. Experimenter 2 (E2) sat directly across from the ape at the table; there was a grate between E2 and the table to block their access to the food (see Figure S1).

Apes first completed 20 *exposure trials* to introduce the prosocial and selfish options (10 trials per option). On each trial, E1 showed the chimpanzee the food, and then placed the food items on a set of two identical plates on one side of the table. One plate was closer to the ape and the other closer to E2 (corresponding to the plates they would receive once the chimpanzee chose and E1 distributed the payoffs). On *selfish trials*, E1 placed a banana only on the plate closer to the ape; the plate closer to E2 was empty. On *prosocial trials*, E1 placed a banana on each plate, and E2 reached for their plate through the grate while making a vocalization, emulating a chimpanzee food-grunt (a vocalization that chimpanzees produce during natural behavior). After 2 seconds, E1 pushed the tabletop forward, so the ape could respond by pointing. E1 then distributed the plates to the chimpanzee and E2; E2 took the food and pretended to eat it if it was a prosocial trial that provided them with food. The side assignment of options was counterbalanced across trials.

Apes then completed 20 *test trials,* where they could choose between the selfish and prosocial options. Here, two sets of plates (e.g., a total of four plates) were placed on the table, one on each side from the chimpanzee's perspective. E1 distributed food to both sets of plates on the table such that one set had a selfish payoff and the other had a prosocial payoff (side counterbalanced; left option always placed first). E2 always reached for the set of plates with the prosocial payoff. Once the ape chose one of the sets, E1 distributed the chosen plates, as in the exposure trials.

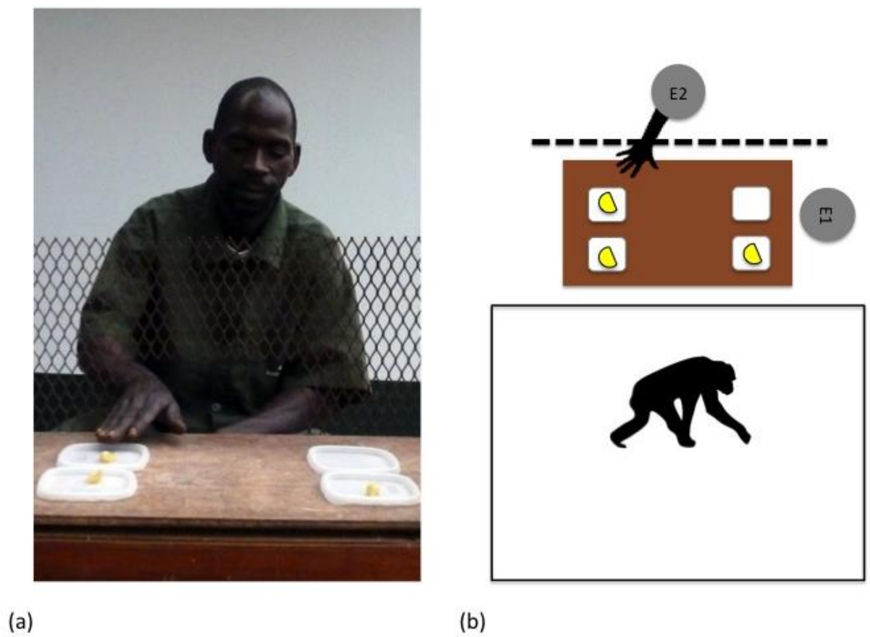

Figure S1: Setup for resource donation task. (a) Photo (from chimpanzee's perspective) of E2 reaching through the grate towards the *prosocial option* (on the left) that provided food for both the chimpanzee and E2; the *selfish option* on the right provided food only to the chimpanzee. (B) Birds-eye diagram of the room setup. E1 sat to one side of the table to distribute the food items across trials.

Coding and reliability

Choices (prosocial or selfish) were coded live by E1. A second coder, who was blind to the hypotheses, coded choices on all trials from videotape (with perfect agreement, Kappa = 1.0). This coder also scored the latency for the subject to choose on each trial, counted from the moment the table was slid forward (so it was flush with the chimpanzee's room) to the moment the chimpanzee protruded a finger through the bars to indicate a choice. We advanced through each video frame-by-frame using the program MPEG Streamclip, and then converted latency in frames back into seconds (30 frames per second). Trials where the chimpanzee was already pointing when the table was pushed forward were coded with a 0s latency. The original experimenter coded 20% of sessions for reliability on latency (with high agreement on latency across coders, $r_p = 0.92$).

Trial-by-trial choice analyses

As noted in the main text, we first examined choices between the prosocial and selfish option. To do so, we fit binomial GLMMs with a logit link function. A base model accounted for *age*, *sex*, and *trial number* (1-20), with *subject* as a random factor. A second model added response *latency* to test the hypothesis that prosocial decisions were made more rapidly than self-interested decisions (see main text for model parameters and likelihood ratio tests). The full model was implemented as follows in R:

glmer (Prosocial_Choice ~ (1|Subject) + Age + Sex + Trial_Number + Latency, family = binomial (link = "logit"))

As reported in the main text, we found that latency to choose was a significant predictor of prosocial choices in test trials. We also examined whether shorter decision latencies predicted prosocial responses in initial exposure trials, where chimpanzees only had one option available at a time. We followed the same procedure and model equations as described for choice trials, and found that latency was not related to choices in exposure trials [see Table S2 for model parameters].

Factor	*Estimate*	*S.E.*	*Z*	*P*
Age (in years)	-0.001	0.012	-0.066	> 0.25
Sex (*female* reference)	-0.004	0.150	-0.026	> 0.25
Trial (1-20)	0.001	0.012	0.091	> 0.25
Latency (in seconds)	-0.088	0.117	-0.760	> 0.25

Table S2: Factors influencing propensity to choose the prosocial option in donation task exposure trials. Predictors from the full (best-fit) generalized linear mixed model. *Age*, *sex*, *trial* number, and a random *subject* factor were included across models, and response *latency* was added to a second model to test its importance.

We then performed an additional check to assess whether trials coded with extreme latencies drove this result. In particular, we removed all trials coded with a zero latency (e.g., because the chimpanzee had already extruded their finger to indicate their choice prior to the table being pushed forward), and limited the maximum length of trial latencies to 2s, as very few exhibited long outlier latencies exceeding 2s (only ~2% of trials). This allowed us to check if either extremely short or long latencies drove this finding. In fact, we found the same results with this reduced data set. Including latency as a predictor significantly improved model fit examining prosocial choices during choice trials [*LRT*: $\chi^2 = 6.62$, $df = 1$, $p = 0.01$], but did not for exposure trials [*LRT*: $\chi^2 = 0.28$, $df = 1$, $p > 0.25$], the same results we reported for the full dataset.

Trial-by-trial latency analyses

As described in the main text, we also examined latencies to choose the prosocial and selfish option on a trial-by-trial basis. To do so, we fit linear mixed models using the lmer function. A base model accounted for *age*, *sex*, and *trial number* (1-20), with *subject* as a random factor. A second model added choice (on that trial) to test whether prosocial choices were made more quickly than selfish ones; and a third model included overall (mean) preference for the prosocial option to test whether this pattern depended on overall preferences. The full model was implemented as follows in R:

lmer (Latency ~ (1|Subject) + Age + Sex + Trial_Number + Choice + Mean_Preference)

As reported in the main text, including *choice* on a particular trial did improve model fit, whereas a subject's *mean preference* for the prosocial option overall did not [see Table S3 for parameters from the full model]. We then conducted the same analysis for exposure trials. In contrast to the results from test trials, we found that neither trial *choice* nor mean *prosocial preference* improved model fit compared to the base model [choice model *LRT*: $\chi^2 = 0.043$, $df = 1$, $p > 0.25$; prosocial preference mode: *LRT*: $\chi^2 = 1.76$, $df = 1$, $p = 0.19$].

Factor	*Estimate*	*S.E.*	*t*	*P*
Age (in years)	0.002	0.007	0.374	> 0.25
Sex (*female* reference)	-0.091	0.082	-1.102	> 0.25
Trial (1-20)	-0.002	0.003	-0.816	> 0.25
Choice (*selfish* reference)	**-0.071**	**0.031**	**-2.307**	**= 0.021**
Mean Prosocial Preference	-0.362	0.306	-1.181	= 0.25

Table S3: Factors influencing latency to choose in donation test trials. Predictors from the full (best-fit) linear model. *Age*, *sex*, *trial* number, and a random *subject* factor were included across models; *choice* and *overall (mean) prosocial preference* were added to successive models to test their importance.

We then again performed an additional check to assess if trials coded with extreme latencies drove this effect, as described above. We found that including choice (prosocial or selfish) modestly improved model fit examining prosocial choices during choice trials [*LRT*: $\chi^2 = 3.79$, $df = 1$, $p = 0.052$], but including mean prosocial preference as an additional predictor did not [*LRT*: $\chi^2 = 2.41$, $df = 1$, $p = 0.12$]. Thus, we found largely similar results to those reported in the main text, even with this reduced dataset.

Instrumental Helping Task

This task assessed whether chimpanzees helped a human by handing over an out-of- reach object for which the human was actively reaching (see Figure S2 and Movie S2). We followed the basic procedure for the instrumental helping tasks from Warneken & Tomasello [18] and Warneken et al. [19], which showed that chimpanzees are much more likely to hand over the object when a human is reaching for it (i.e., showing need) compared to a control condition when the human purposefully throws the object and, therefore, does not need help.

Procedure

Apes completed 10 trials, each lasting up to one minute. On each trial, E1 sat at the testing table playing with a stick (approximately 10 cm long, painted green). Three small pieces of food were placed on the table to attract the chimpanzee to the starting location. After 10 seconds, E2 approached and struggled with E1 for the stick. E2 then walked across the room (to a spot approximately 2m from the table), tossed the stick into the subject's room, and left the testing area. E1 then approached the room where the stick had been thrown and indicated desire for it by reaching towards it (see Figure S2). In the first 30 seconds, E2 vocalized (an effortful grunting sound) but focused only on the object. If the ape did not retrieve the stick within 30 seconds, E1 began to call the subject's name and alternated gaze between the subject and the object. The trial stopped after 1 minute or when the chimpanzee gave the stick to the experimenter; durations were timed with a stopwatch. This task was filmed with two cameras, one focused on the part of the room where E2 deposited the stick, and one filming the entire wall of the chimpanzee's room.

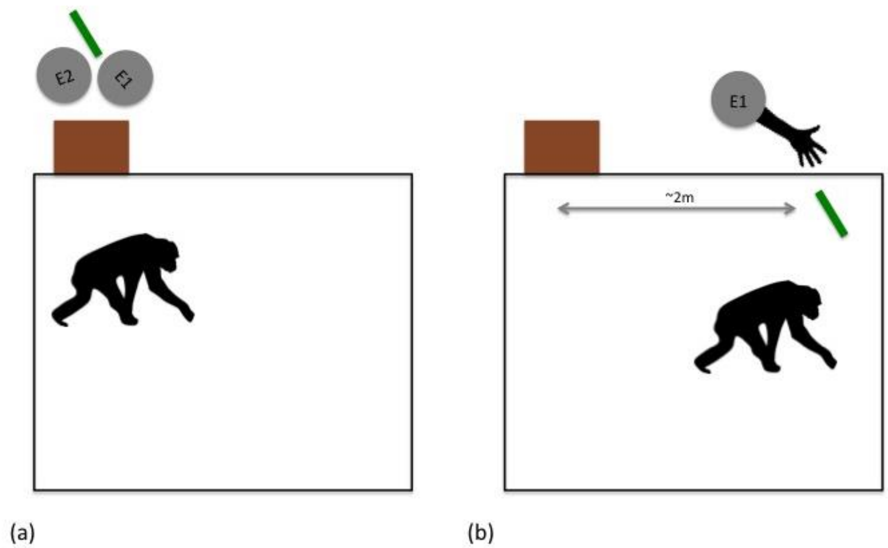

Figure S2: Setup for instrumental helping task. (a) E1 sat at a table playing with a stick, and E2 then approached and struggled with her for the stick. (b) E2 walked approximately 2m away and threw the stick into the chimpanzee's room. E1 approached the stick and reached for it for up to 1 min.

Coding and reliability

Whether or not the chimpanzee provided the stick was coded live by E1. A second coder, who was blind to the hypotheses, coded choices on all trials from videotape using the program (with perfect agreement, Kappa = 1.0). This coder also scored the latency for the subject to provide the stick, starting from the moment E1 began reaching for the stick (with a maximum latency of 60s; E1 timed trials with a stopwatch live). The original experimenter coded 20% of sessions for reliability on latency to help with high agreement [$r_p = 0.99$].

Main analyses: individual variation in helping and latency

As noted in the main text, we first examined how mean frequency to help was related to mean response times. To do, we used multiple linear regression first fit a model of mean helping responses accounting for *age* and *sex*; in a second model, we then added *mean response latency* to test whether faster individuals were more prosocial overall. The full model was implemented with the following equation in R:

lm (Helping_Mean ~ Age + Sex + Latency_Mean)

Supplemental Analyses: trial-by-trial helping

To examine patterns of helping across trials, we first fit a binary GLMM model with a logit link function accounting for *age* and *sex*, and random *subject* intercepts (using the basic equation for GLMMs noted previously). In a second model, we then included *trial number* (1-10) to examine if patterns of helping changed over trials, and this did not improve model fit [*LRT*: $\chi^2 = 0.16$, $df = 1$, $p > 0.25$; see Table S4 for full model parameters]. This procedure and code followed those used in the trial-by-trial analyses of the donation task (see previous section).

Factor	*Estimate*	*S.E.*	*Z*	*P*
Age (in years)	0.054	0.095	0.573	> 0.25
Sex (*female* reference)	-1.100	1.212	-0.904	> 0.25
Trial (1-10)	0.022	0.054	0.406	> 0.25

Table S4: Factors influencing propensity to help. Predictors from the full (best-fit) model. *Age*, *sex*, and a random *subject* factor were included across models. *Trial* number was added to a second model to test its importance.

Punishment Task

This task assessed whether apes punished a culpable human experimenter for stealing their food by collapsing the table the food was on (see Figure S3 and Movie S3). We used the basic procedure from Jensen et al. [20], which showed that chimpanzees preferentially punish conspecifics who steal their food (compared to when they are not directly culpable of theft).

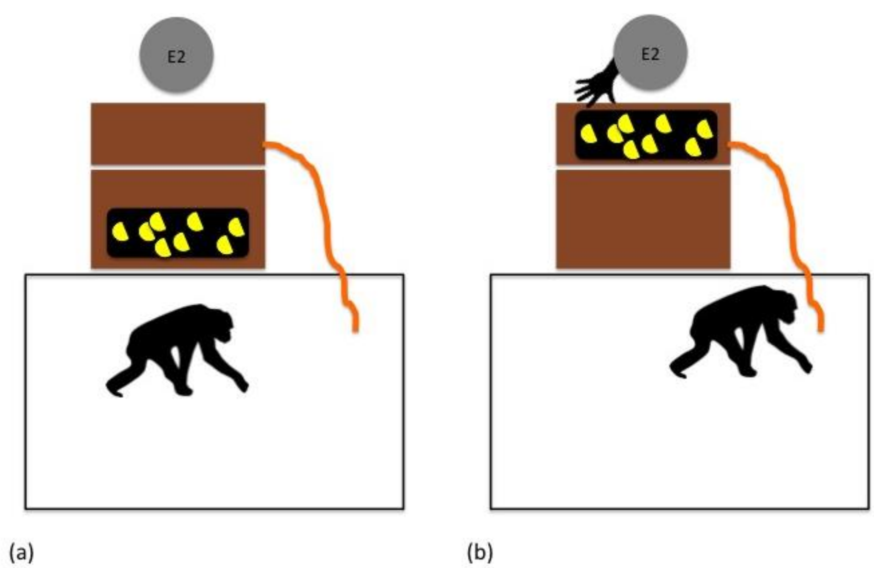

Figure S3: Setup for punishment task. (a) E1 sat across from the chimpanzee at a table with a collapsible wing (on E2's side); a rope (in orange) was attached to a post propping up the wing and threaded into the chimpanzee's room. For 5s, the chimpanzee had access to a large tray of food. (b) E2 then pulled the tray over to his side and pretended to eat the food for up to 1 minute, or until the chimpanzee collapsed the table by pulling the rope.

Procedure

Apes sat at a table with a collapsible wing; the side closest to the chimpanzee was stable, whereas the side farther away was collapsible. A post was positioned under the wing, and a rope attached to the post was threaded through to the chimpanzee's room, so the ape could collapse the wing by pulling on the rope. (The contents of the table fell out of the chimpanzee's reach.)

In two initial *exposure trials*, E1 first threaded the rope into the ape's room (approximately 1ft protruding through the bars). She then placed a tray with inedible items (familiar rocks) on the collapsible side of the table. These trials served to ensure that the ape knew how to collapse the table and had seen the physical effect of doing so. If the chimpanzee did not pull after 1 minute, E1 attracted attention to the rope to facilitate pulling. If the chimp did not pull after 2 minutes, E1 placed a small piece of banana on the rope to give incentive to pull. Latency to pull on these exposure trials was coded, with a maximum latency of 3 min when these additional measures were taken.

On the following 10 *test trials*, E2 sat across from the ape (at the collapsible side; see Figure S3). As in exposure trials, E1 threaded the rope into the ape's room and placed a tray on the table, but here the tray contained food (a mixture of banana slices and peanuts) and was placed on the chimpanzee's side. Chimpanzees had access to the tray for 5 seconds (which was too short for the chimpanzee to access more than a few pieces of food). Then E2 grabbed the tray and pulled the food to his side of the table (the collapsible wing). For up to one minute (or until the chimpanzee collapsed the table), E2 pretended to slowly eat the food. Each trial was timed with a stopwatch. This task was filmed with two cameras, one focused on the table and one filming the entire wall of the chimpanzee's room.

Coding and reliability

Whether or not the chimpanzee collapsed the table was coded live by E1. A second coder, who was blind to the hypotheses, coded choices on all trials from videotape using the program (with perfect agreement, Kappa = 1.0). This coder also scored the latency for the subject to respond from the moment E2 moved the tray to the collapsible side of the table. The original experimenter coded 20% of sessions for reliability on latency to punish (with high agreement, $r_p = 0.99$).

Main analyses: individual variation in punishment and latency

As noted in the main text, we first examined how mean frequency to punish was related to mean response times. To do so, we used the same general approach as for the helping analysis. We used multiple linear regression to first fit a model of mean punishment responses accounting for *age*, *sex, and* mean *exposure response latency* (to account for each individual's speed to collapse the table in nonsocial exposure trials); in a second model, we then added *mean response latency* in the test trials to examine whether faster individuals punished more overall. The full model was implemented as follows in R:

lm (Punish_Mean ~ Age + Sex + Exposure_Latency + Test_Latency)

Supplemental Analyses: trial by trial punishment

To examine patterns of punishment across trials, we used binomial GLMM models with a logit link function (using the basic notation described previously). A base model included *age* and *sex,* with random *subject* intercepts; we then included *trial number* (1-10) in a second model to examine if patterns of punishment changed over trials. However, this did not improve model fit [*LRT*: $\chi^2 = 0.003$, $df = 1$, $p > 0.25$; see Table S5 for full model parameters], indicating stable choices across the session.

Factor	*Estimate*	*S.E.*	*Z*	*P*
Age (in years)	0.035	0.088	0.396	> 0.25
Sex (*female* reference)	-1.307	1.135	-1.152	= 0.25
Trial (1-10)	-0.003	0.058	-0.058	> 0.25

Table S5: Factors influencing propensity to punish. Predictors from the full (best-fit) model. *Age*, sex, and a random *subject* factor were included across models. *Trial* number was added to a second model to test its importance.

Intertemporal Choice Task

This task assessed the chimpanzee's decisions about tradeoffs between rewards and time costs when they faced choices between a smaller reward (one piece of food) available immediately and a larger reward (three pieces) only available after a one-minute delay (see Figure S4 and Movie S4). We followed the basic procedure used in Rosati and Hare [21].

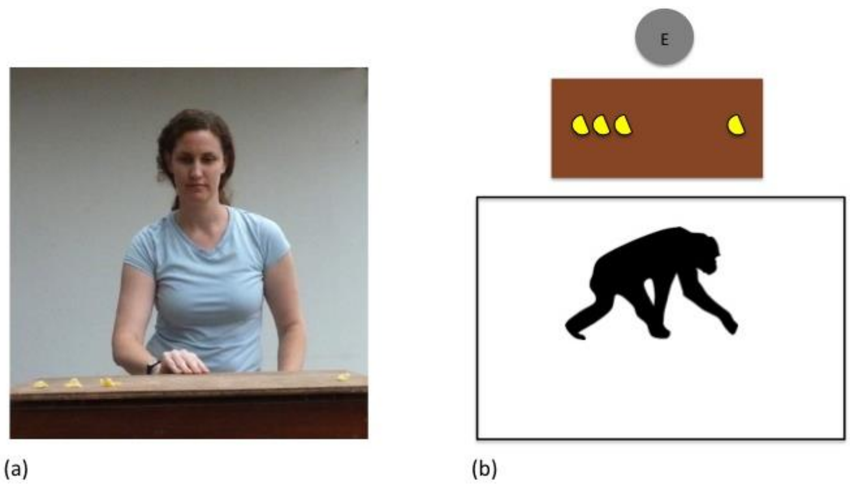

Figure S4: Setup for temporal discounting task. (a) Photo of setup (from chimpanzee's point of view): E sat across from the chimpanzee at a table, placing the smaller, immediate reward and larger, delayed reward on opposite sides of the table. (b). Birds-eye diagram of setup.

Number pretest

Subjects first completed four number discrimination trials (1 versus 3 pieces), where both rewards were both available immediately. This pretest gave us a baseline measure of chimpanzees' preference for larger rewards. It also served to ensure all chimpanzees were familiar with the basic procedure for making dichotic choices by pointing, as this was the first task in the battery involving such a setup. On each trial, both options were placed in the middle of the table (approximately 10 cm apart), and the ape could indicate choice by pointing at one option. These trials involved peanuts to better distinguish these trials from the main discounting task (where the apes had to wait delays to receive the larger rewards).

Test session

Immediately following the number pretest, the chimpanzees completed the main discounting task. Here, apes chose between one slice of preferred food (banana) available immediately and three slices following a one-minute delay. Apes first completed 8 initial *exposure* *trials,* in which only one option was available at a time, in order to introduce the relevant amounts and delays. There were two possible orders for the exposure trials (e.g., small, immediate or large, delayed reward) that were counterbalanced across subjects; the side assignment of the rewards was counterbalanced within the session.

Next, chimpanzees completed 14 *test trials,* in which they chose between the two options (side assignment counterbalanced within the session). Here, E placed the two options on opposing sides of the table (left side first) and then pushed the table forward for choice (see Figure S4). If the ape chose the small, immediate option, E gave it to them immediately. If the ape chose the larger, delayed option, E removed the smaller reward, leaving only the larger reward on the table for a one-minute delay. Once the delay concluded, E gave the chimpanzee the food. There was a 20s inter-trial interval (ITI) between trials, starting when the chimpanzee placed the last piece of food in their mouth.

Coding and reliability

Choices (for smaller or larger option) were coded live by the experimenter. A second coder, who was blind to the hypotheses, coded choices on all trials from videotape (with perfect agreement, Kappa = 1.0).

Supplemental Analyses: trial-by-trial discounting choices

To examine binary trial-by-trial responses in the discounting task, we used the same approach to analyze trial-by-trial data as in the prior tasks. We fit binomial GLMM models with logit link function. A base model accounted for *age*, *sex, trial number* (1-14), and random *subject* intercepts to account for repeated measurements. In a second model, we then included *trial type* (number pretest or test trials) to examine if chimpanzees chose the larger reward more often in the number pretest where there was no delay imposed, versus the test trials where they had to wait for the larger reward. This did improve model fit [*LRT*: $\chi^2 = 6.69$, $df = 1$, $p = 0.01$; see Table S6 for full model parameters], indicating that apes were sensitive to the costs associated with waiting.

Factor	*Estimate*	*S.E.*	*Z*	*P*
Age (in years)	-0.024	0.018	-1.332	0.18
Sex (*female* reference)	0.056	0.231	0.240	> 0.25
Trial (1-14)	-0.032	0.022	-1.424	0.15
Trial Type (*number* reference)	**-0.633**	**0.249**	**-2.543**	**0.011**

Table S6: Factors influencing choices in the intertemporal choice task. Predictors from the full (best-fit) model. *Age*, *sex*, *trial number* and a random *subject* factor were included across models. *Trial type* (number pretest versus delay test trials) was added to a second model to test its importance.

Supplemental Analyses: Modeling discounting choices as a function of cooperation tasks

We also fit linear regression models relating these cooperation measures to discounting performance. A base model accounted for *age*, *sex, and number pretest performance.* Across subsequent models, we added mean *donation* rate [*LRT*: $\chi^2 = 0.22$, $df = 1$, $p > 0.25$ mean *helping* rate [*LRT*: $\chi^2 = 1.11$, $df = 1$, $p > 0.25$], and mean *punishment* rate [*LRT*: $\chi^2 = 0.36$, $df = 1$, $p > 0.25$], none of which, individually or together, improved fit compared to the base model (see table S7 for full model including all possible predictors). Thus, there was no evidence that discounting performance was related to performance in the social tasks.

Factor	*Estimate*	*S.E.*	*t*	*P*
Age (in years)	-0.004	0.005	-0.909	> 0.25
Sex (*female* reference)	0.010	0.060	0.169	> 0.25
Number pretest	0.151	0.149	1.014	> 0.25
Mean donation rate	0.089	0.229	0.387	> 0.25
Mean helping rate	-0.076	0.075	-1.006	> 0.25
Mean punishment rate	0.053	0.099	0.535	> 0.25

Table S7: Factors influencing mean preference for the larger, delayed reward across individuals in the intertemporal choice task. Predictors from the full model. *Age*, *sex*, and *number pretest performance* were included across models. Donation rate, helping rate, and punishment rate were then added individually to subsequent models to test their importance.

Go/no-go Task

This task assessed whether apes inhibited a pre-potent response when given a signal that they should not make it, measuring inhibitory control over motor responses [22]. As most human studies involve computer-based tasks that are not feasible at this site, we developed a novel go/no-go task for apes. Chimpanzees were introduced to two (visually-distinct) objects; if they touched the "*go" option* they received a piece of food, whereas if they touched the "*no-go" option* it was thrown in the trash (see Figure S5 and Movie S5).

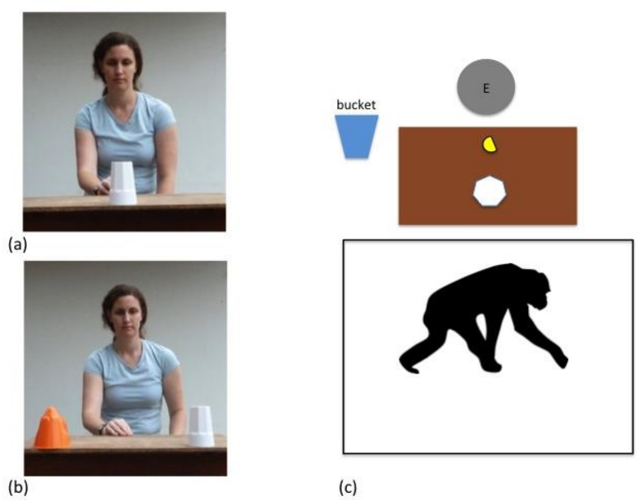

Figure S5: Setup for go/no-go task. (a) Photo of setup: On *exposure* and *test trials*, E placed one cue option on the table, along with a piece of food (the food was visible but out of reach). E gave the chimpanzee the food if they touched the "go" option, but threw the food away if they touched the "no-go" option. (b) In l*earning trials*, apes had to demonstrate a preference for the "go" option by choosing it over the "no-go" option in a binary choice. (c) Bird's-eye diagram of setup, including trash bucket next to E.

Procedure

Apes were first introduced to the effects of two visually distinct objects (an orange cone-shaped object and a white cup; assignment of the objects to the cues was counterbalanced across subjects). If apes touched the "*go: option*, they received food, whereas if they touched the "*no-go" option*, then the food was thrown away. Apes first experienced this distinction in 20 initial *exposure trials.* Here, the experimenter (E) placed a banana at the end of the table farthest from the ape (out of the ape's reach), while simultaneously placing one of the objects at the front, center of the table nearest the ape. If the trial involved the "go" option, E gave the ape the banana once they touched the object. In contrast, on trials involving the "no-go" option, E threw the banana into a bucket if the ape touched it, an outcome the apes found aversive (see Figure S5). These initial exposure trials were grouped in alternating blocks of five trials per option (order counterbalanced across subjects).

On subsequent *learning trials*, the apes had to preferentially choose the "go" cue over the "no-go" cue in a series of binary choices. Here, E placed the two options on opposite sides of the table (side counterbalanced across trials), and the ape had to choose the correct cup on 10 of the last 12 trials to reach criterion and proceed to the test phase. If they did not pass in the first 30 trials, they repeated the exposure phase (another 20 trials alternating the go and no-go options in blocks of five). They then completed another 30 learning trials. If apes did not reach criterion within this second set of learning trials, they repeated the session the next day. (All of these chimpanzees then met criterion and proceeded to the test phase.)

In 40 subsequent *test trials*, the procedure followed that in the exposure trials, except the majority of trials (80%) involved the "go" cue to create a pre-potent response bias; only a small number of interspersed trials (20%) involved the "no-go" cue. As in exposure trials, if apes correctly responded to the container on "go" trials, they received the food. However, on "no-go" trials, the banana was thrown in the bucket if they responded. Trials lasted up to 10s if the apes successfully inhibited their response, at which point E would begin the next trial. Apes experienced one of two possible orders for these trials (both randomly-determined), with trial order counterbalanced across subjects.

Coding and data analysis

The experimenter coded the subject's choices on learning trials live. A second coder, who was blind to the hypotheses, coded choices in learning trials from videotape (with perfect agreement, Kappa = 1.0). This coder also scored the latency for the subject to respond to the options on exposure and test trials, scoring the moment the table was slid forward (so it was flush with the chimpanzee's room) to the moment the chimpanzee protruded fingers or touched the object (whichever consistently indicated a chimp's choice). We advanced through each video frame-by-frame, and then converted frames back into seconds (30 frames per second). If the chimpanzee withheld a response for the full 10s, their latency was coded as this maximum latency. Trials where the chimpanzee was already pointing when the table was pushed forward were coded with a 0s latency; additional analysis checks removing these trials revealed that the same basic results reported below held. The original experimenter coded 20% of sessions for reliability on latency to choose (with high agreement, $r_p = 0.98$).

Supplemental Analyses: trial-by-trial go/no-go responses

The reaction time data from the go/no-go task had a strong positive skew, as is typical of similar reaction time data. Consequently, we examined trial-by-trial responses using GLMM models with a gamma distribution and log link, following recommendations for data with this distribution [23, 24]; 0s response latencies were converted to 0.001 responses in this analysis because gamma distributions do not allow non-positive values. An initial model included *age*, *sex*, *trial number* (1-14), and random *subject* intercepts. In a second model, we then included *cue type* ("go" versus "no-go") to examine if chimpanzees had slower reaction times to no-go cues. This did improve model fit [LRT: $\chi^2 = 204.0$, $df = 1$, $p < 0.0001$; see Table S8 for full model parameters], indicating that apes were sensitive to the different cues and withheld their responses for a longer period in response to "no-go" cues.

Factor	*Estimate*	*S.E.*	*t*	*P*
Age (in years)	0.031	0.018	-1.714	= 0.09
Sex (*female* reference)	0.195	0.223	0.873	> 0.25
Trial (1-40)	**-0.010**	**0.002**	**-4.290**	**< 0.001**
Trial Type (*Go cue* reference)	**0.974**	**0.072**	**13.599**	**< 0.001**

Table S8: Factors influencing responses in the Go/No-go task. Predictors from the full (best-fit) model. *Age*, *sex*, *trial number* and a random *subject* factor were included across models. *Trial type* (go versus no-go cued trials) was added to a second model to test its importance.

Supplemental Analyses: Removing extreme latency values

As described in the main text, our measure of individual differences in the go/no-go test was each chimpanzee's mean change in reaction time in response to "no-go" versus "go" cues (ΔRT). ΔRT was not normally distributed; to ensure that this did not impact our main results, we also examined results removing these trials.

First, we examined trial-by-trail responses removing the zero second latencies 9where individuals were producing a response before the table was already pushed forward). In fact, we found the same basic result reported above and in Table S8: including *cue type* ("go" versus "no-go") improved model fit [LRT: $\chi^2 = 307.6$, $df = 1$, $p < 0.0001$]. Thus, we did not find any evidence that our trial-by-trial results were driven by the zero-second response latencies, as we found the same result even with the reduced dataset.

We also examined inter-task correlations when removing three outlier chimpanzees (whose ΔRT values were above 1.5*IQR (interquartile range) for this population. Yet, the basic results we reported in the main text, finding no relationship with go/no-go performance, was the same for the *donation* task [$n = 35$, $r_p = -0.07$, $p > 0.25$, $BF_{01} = 7.00$], the *helping* task [$n = 36$, $r_p = -0.03$, $p > 0.25$, $BF_{01} = 7.60$], and the *punishment* task [$n = 36$, $r_p = -0.23$, $p = 0.17$, $BF_{01} = 4.66$]. Thus, we found no evidence that go/no-go performance was related to social decision-making, even when accounting for the non-normally-distributed ΔRT data, and these Bayes Factor values provide moderate support for the null hypothesis.

Supplemental Analyses: Modeling go/no-go responses as a function of cooperation tasks

Finally, we fit linear regression models relating these cooperation measures to discounting performance. A base model accounted for *age* and *sex.* Across subsequent models, we added mean *donation* rate [*LRT*: $\chi^2 = 0.002$, $df = 1$, $p > 0.25$ mean *helping* rate [*LRT*: $\chi^2 = 2.04$, $df = 1$, $p = 0.15$], and mean *punishment* rate [*LRT*: $\chi^2 = 0.06$, $df = 1$, $p > 0.25$], none of which, individually or together, improved fit compared to the base model (see table S9 for full model including all possible predictors). Thus, there was no evidence that discounting performance was related to performance in the social tasks.

Factor	*Estimate*	*S.E.*	*t*	*P*
Age (in years)	-0.098	0.052	-1.872	= 0.07
Sex (*female* reference)	0.491	0.634	0.774	> 0.25
Mean donation rate	-0.076	2.346	-0.033	> 0.25
Mean helping rate	1.112	0.833	1.335	= 0.19
Mean punishment rate	-0.257	1.044	-0.246	> 0.25

Table S9: Factors influencing mean preference for the larger, delayed reward across individuals in the intertemporal choice task. Predictors from the full model. *Age*, *sex*, and *number pretest performance* were included across models. Donation rate, helping rate, and punishment rate were then added individually to subsequent models to test their importance.

Social Responsivity Task

This task assessed the chimpanzees' motivation to approach social and nonsocial stimuli (see Figure S6 and Movie S6). We followed the basic procedure from Herrmann et al. [25].

Procedure

Apes completed a series of eight trials, each with the same basic procedure. E1 presented the chimpanzee with various items on a testing table (one item per trial), while E2 stood approximately 2m away to center the chimpanzee for the start of each trial (see Figure S6). On each trial, E2 attracted the ape to the starting position using a small piece of food. Once the ape was centered, E1 said start, and E2 gave the food to the chimpanzee. E1 then placed the relevant object on the table. E2 walked away after centering the ape, so they were not visible during the trial. Each trial lasted 30 seconds (timed with a stopwatch), and E1 always looked down and did not interact with the ape on trials for which she was present. This allowed us to measure the subject's latency to approach and the duration within arm's reach of the table from the fixed starting location. The test was filmed with two cameras, one filming the whole room, and the other angled from above to film a 42"x42" square in front of the table (this angle was used for coding).

Trial types

Apes completed 8 trials comprising four trials where the object or event of interest was social (*Person, Vocalization, Male Photo, Female Photo*), and four where the primary object was nonsocial (*Baseline, Food, Stationary Object, Moving Object*). Chimpanzees completed these trials in the following order:

1. Baseline: No person or object was present at the table.
2. Person: E1 was present at the table. (She looked down and did not respond to the ape).
3. Food: E1 placed food (a banana slice) on the table, out of the chimpanzee's reach.
4. Stationary object: E1 placed a novel object (an orange fish toy) on the table.
5. Moving object: E1 placed novel object that moved (an animate rolling ball inside a container tray) on the table.
6. Vocalization: E1 placed a large bucket on the table and produced an emotional vocalization, simulating a chimpanzee *waa*-bark, while looking inside.
7. Male photo: E1 placed a large photo (8.5 x 11") of an unfamiliar adult male chimpanzee (from the Kanyawara community in Uganda) on the table.
8. Female photo: E1 placed a large photo of an unfamiliar adult female chimpanzee's swelling (from the Kanyawara community in Uganda) on the table.

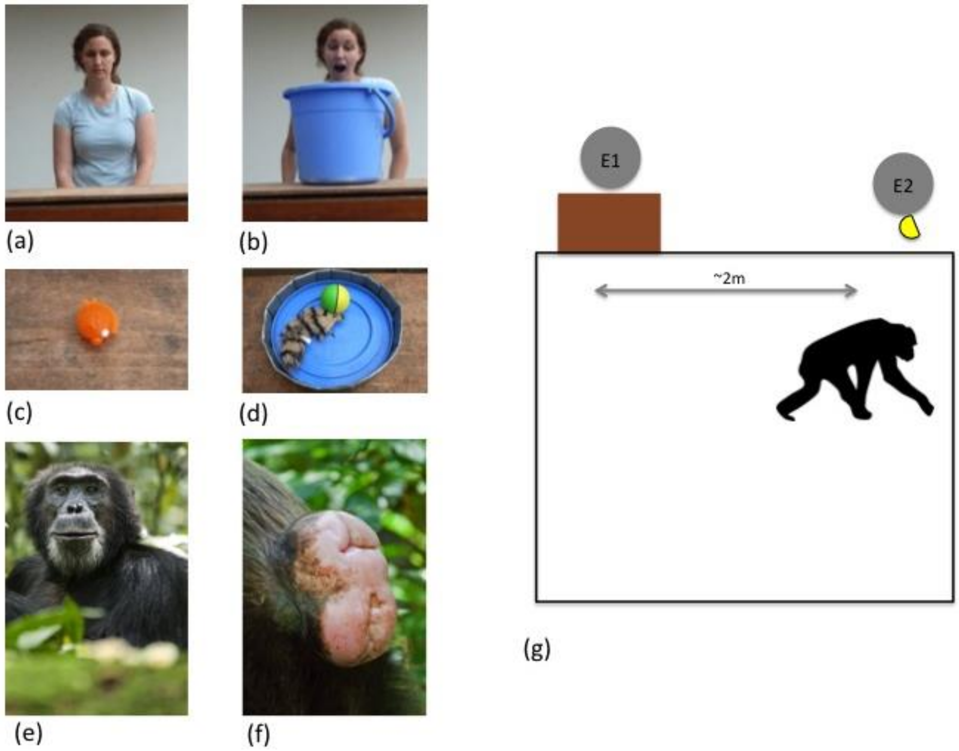

Figure S6: Setup for social responsivity task. (a) Photo of *Person* trial. The *Baseline* trial was identical except that no person was present (only the table), and the *Food* trial was identical except that E placed a piece of food on the table (out of the chimpanzee's reach). (b) Photo of *Vocalization* trial. (c) Novel *Stationary object*. (d) Novel *Moving object* (rolled around in tray). (e) *Male photo* stimulus. (d) *Female photo* stimulus. (g) Bird's-eye diagram of setup showing where E2 centered the chimpanzee and the location of E1 sitting at the testing table.

Coding and analysis

The experimenter scored whether the ape approached the table within 30 seconds live. A second coder, who was blind to the hypotheses, scored the latency for the subject to approach within arm's reach of the table (from the moment E1 placed the object of interest on the table), as well as each chimpanzee's total duration in the vicinity of the table. For coding, we used the high camera angle that filmed a square area of the chimpanzee's room in front of the table. The original experimenter coded 20% of sessions for reliability on latency to respond and total duration at the table (latency to approach: $r_p = 0.96$; duration of time spent at table: $r_p = 0.99$).

Supplemental analyses

We examined only those trials where subjects approached at all in the trial; one chimpanzee did not approach on the majority of trials and was excluded from these analyses. Overall, chimpanzees approached both social and nonsocial stimuli at similar latencies [social $M = 5.97$s, nonsocial $M = 5.66$s; paired samples t-test: $t_{38} = 0.63$, 95% CI of the mean difference = [-0.69, 1.32], $p > 0.25$, *Cohen's D* = 0.10]. To examine the relationship of social and non-social approach latency with the cooperative measures, we used multiple linear regression. A base model included each subject's *sex*, *age*, and *mean nonsocial latency* (to control for general speed to approach the table) to predict mean cooperation frequencies; then, in a second model we included *mean social* *latency* to test its effect. We found that including social latency in the donation model improved fit [*LRT*: $\chi^2 = 4.20$, $df = 1$, $p = 0.04$]: slower latencies to approach social items predicted more prosocial responding [*Estimate*: 0.015, $SE = 0.008$, $t = 1.96$, $p = 0.058$]. Including social latency in the helping model also improved fit [*LRT*: $\chi^2 = 6.89$, $df = 1$, $p = 0.009$], but here *faster* latencies to approach social items predicted more prosocial responding [Estimate: -0.053, SE = 0.021, $t = -2.564$, $p = 0.015$]. Finally, including social latency in the punishment model did not improve fit *[LRT:* $\chi^2 = 0.29$, $df = 1$, $p > 0.25$].

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Supplemental Movies Captions

Movie S1: Resource Donation Task. Chimpanzees chose between a *prosocial* option that provided food to themself and another individual, and a *selfish* option that provided food only to themself. Experimenter 1 (E1) sat to the side of the table and distributed the food (with side assignment for the options counterbalanced across trials), whereas E2 (the recipient) sat across from the chimpanzee. E2 could not access the food due to an additional grate between them and table, but they indicated their desire for the prosocial option by reaching for it effortfully through the grate. Here, the chimpanzee first selects the selfish option and then the prosocial option.

Movie S2: Instrumental Helping Task. E1 plays with a stick when E2 approaches and tries to take the stick; after a struggle, E2 steals the stick and tosses it into the chimpanzee's room. For up to 30s, E1 reaches for the stick and makes an effortful noise without interacting with the chimpanzee. If the chimpanzee does not give them the object during that time, E1 then switches to directly recruiting the chimpanzee by calling their name and alternating gaze direction between the chimpanzee and stick for up to another 30s. Here, the chimpanzee gives E1 the stick in the first half of the trial.

Movie S3: Punishment Task. E1 places a large tray of food on a table in front of the chimpanzees; E2 sits across from the chimpanzee at a collapsible wing of the table held up by a removable leg. E1 previously threaded a rope attached to this leg into the chimpanzee's room. After 5s, E2 steals the tray of food from the chimpanzee and pretends to eat the food. Here, the chimpanzee collapses the table by using the rope to pull out the removable leg from underneath the table wing.

Movie S4: Temporal Discounting Task. The experimenter places the smaller, immediately-available reward (one raw banana slice) on the left and the larger, delayed reward (three raw slices, available after one minute) on the right, with side assignment counterbalanced across trials. Prior to choice trials, chimpanzees experienced the associated quantities and delays in exposure trials with only one option available at a time. Here, the chimpanzee chooses the smaller, immediate reward in the first clip, and the larger, delayed reward in the second clip.

Movie S5: Go/No-Go Task. The experimenter places a piece of food on the far end of the table (out of the chimpanzee's reach) and an object cuing the chimpanzee as to whether it is "go" or "no-go" trial in the center of the table, near the chimpanzee. If chimpanzees emit a response to the "go" object (here, a white overturned cup) by touching it, E gives them the food. In contrast, on trials where E presents the "no-go" option (here an overturned orange container, with cues counterbalanced across chimpanzees), if chimpanzees emit a response, E throws the food away. Here, the chimpanzee emits a response to both cue types, but hesitates before the "no-go" cue.

Movie S6: Social Responsivity Task. Across eight distinct trials, chimpanzees were presented with four social and four non-social stimuli. In each trial, E1 placed a stimulus on a testing table, while E2 initially centered the chimpanzee at a distance 2m away. E2 then left when the trial started, and the chimpanzees' latency to approach the stimulus was examined (within a trial lasting 30s). Here, the chimpanzee was slower to approach a person and relatively faster to approach a novel object placed on the table.