Supplementary Figure Legends

Figure 1. Move sequences and last move timing. **a-e:** Movement trajectory analysis of an example pair of human players in 50 consecutive trials. **a:** Movement trajectories of the kicker. **b:** All 50 trials categorized by sequential movement combinations, showing the dominant strategy types (up-down and down-up). **c:** Kicker trajectories broken down into 4 strategy types: S1-ball going straight up; S2-ball going straight down; S3-ball going down and then up; S4-ball going up and then down. X axis, time. Y axis, normalized vertical axis on screen. Circles mark ball direction change. Blue, kicker losing trials; cyan, kicker winning trials. **d:** Average trajectories for the 4 kicker strategy types. X axis, time. Y axis, normalized vertical axis on screen. Thick lines, mean trajectories; thin lines, mean ± SEM. **e:** Distributions of kicker first and last move time, showing one single peak for last but not first move time. **f:** Average ball trajectories for all S3 (down-up) and S4 (up-down) trials in which human (**left**) and monkey (**right**) kickers timed the last move 1) before, 2) within, and 3) after the optimal window. Straight red line represents the goalie bar. X axis, time. Y axis, normalized vertical axis on screen. **g:** For both humans (**left**) and monkeys (**right**), wider distributions of kicker last move time were correlated with lower kicker win rates. Average last move S.E.M. and win rate for monkey kickers are superimposed for comparison. Straight line, linear fit. **h:** Goalies making last move before kickers was associated with higher win rates for goalies. Error bars, mean ± SEM. **i:** Kicker win rates for all kicker-goalie combinations. -K: unskilled kicker, -G: unskilled goalie; +K: skilled kicker; +G: skilled goalie. Monkey win rates are superimposed for comparison. **j:** Skilled kickers improved their last move timing across trials. This trend did not exist in unskilled kickers or monkeys.

Figure 2. Strategies beyond last move timing. **a:** The overall displacement of the ball was positively correlated with kicker winning. Error bars, mean ± SEM. **b:** The frequency of each of the 4 movement combinations for all human (**left**) and monkey (**right**) kickers, and the corresponding win rates. **c:** Trial-by-trial cross correlations between kicker's and goalie's total number of moves. **d:** Trial-by-trial cross correlations between kicker's trial outcome and their likelihood to repeat last trial move sequence. **e:** Trial-by-trial correlations between kicker trajectory similarity (compared with last trial) and kicker-goalie Y distance, for both humans (**left**) and monkeys (**right**). **f:** Partial correlations between kicker last trial and goalie current trial trajectory, regardless of kicker current trajectory. **g-h:** Population gaze pattern heat maps for human (**g**) and monkey (**h**) kicker (**left**), goalie (**middle**), and goalie minus kicker (**right**). Goalies predominantly tracked ball positions whereas kickers focused on the finish line/goalie bar. X and Y axes: normalized horizontal and vertical axes on screen.

Figure 3. Psychological traits predicting human performance in penalty kick game. **a-c:** Human kickers' and goalies' win rates were correlated with their current risk-taking index (RTI, **a**), functional impulsivity (Dickman's Impulsivity Inventory, DII, **b**), and maximizing tendency (Brief Maximizing Scale, BMS, **c**). Lines, linear regression fits. **d:** Human goalies' but not kickers' win rates were correlated with "ability to modify self-presentation" score of the revised self-monitoring scale (RSMS). **e:** Human goalies' but not kickers' win rates were correlated with "emotional stability" score of the Ten Item Personality Inventory (TiPi). **f:** Estimated coefficients

for all questionnaire scores deemed significant by the elastic net model. **g-i:** Kicker functional impulsivity (**g**) as well as kicker (**h**) and goalie (**i**) agreeableness most significantly predicted game outcome in skilled kicker-skilled goalie pairs.

Table. A summary of all elastic net results for all questionnaire scores predicting kicker win rate (**t1**), kicker total number of moves/last move timing/last move optimality (**t2**), and goalie total number of moves/last move reaction time/percentage of trials matching kicker number of moves (**t3**). Only significant results are indicated by numbers. Magenta boxes indicate factors that are significant in predicting both kicker and goalie performance.

Figure 4. Gaussian Process (GP) classification models; single-unit recordings in mSTS. **a:** The predicted probabilities of movement derived from the GP models plotted together with actual probabilities of movement for both kickers. **b:** Sensitivities for each model parameter in each trial (dark to light gray colors corresponding to early to late trials) in a policy GP model (kicker L-goalie B). TSLC: time since last change. LTO: last trial outcome. **c:** Average sensitivities for each model parameter in kicker and goalie policy GP models, split by the first and second half of the trial. **d:** Structural magnetic resonance image (monkey B, **top:** coronal; **bottom:** parasagittal) overlaid with estimated recording sites indicated by the red oval. LS, lateral sulcus. Monkey L's recording site coordinates were very similar to monkey B's. **e:** Example PSTHs for simultaneously recorded mSTS neurons in goalie winning trials (normalized to pre-trial baseline). Grey lines, beginning and end of trials. **f:** Example PSTHs for the same mSTS neurons across player roles and different trial outcomes (normalized to pre-trial baseline). **g:** Spontaneous firing rates of type I and type II neurons during kicker and goalie trials. Error bars, mean ± SEM. h: **h: Left:** Neurons that tracked self movement also encoded self-regarding sensitivities such as LTO. **Right:** By contrast, neurons high in tracking other movement were low in encoding self-LTO. Straight line, linear fit. **i:** Mean firing rate per trial for an example type II neuron in goalie trials, plotted over the corresponding final goalie-kicker Y difference for the same trials. White blocks: goalie winning trials; gray blocks: goalie losing trials.

Figure 5. mSTS firing rate is modulated by social context. **a:** Movement trajectories of kicker and goalie in 100 consecutive trials when a live kicker played a goalie replay. X axis, time; Y axis, vertical axis on screen. Goalie's trajectory is compressed along the X axis. Crosses mark response times; circles mark redirections. Blue lines, kicker trajectories in losing trials; cyan lines, kicker trajectories in winning trials; red lines, goalie trajectories in losing trials; pink, goalie trajectories in winning trials. White line, finish line. **b:** Win rates for monkey kickers and goalies in different conditions. Boxes represent first quartile (Q1) to third quartile (Q3) range; circles denote outliers. **c:** Redirection rates for monkey kickers and goalies in different conditions. Error bars, mean ± SEM. **d:** Population PSTHs for all mSTS kicker (**left**) and goalie (**right**) neurons in winning trials across different social contexts. Grey lines mark the beginning and end of trials. Line thickness represents mean ± SEM. **e:** Movement trajectories of kicker and goalie for 100 consecutive trials in the separate rooms condition. **f:** Population PSTHs for all mSTS neurons recorded in separate rooms condition. **g:** Normalized firing rates of mSTS neurons recorded in face to face live as well as replay, decoy, or separate rooms conditions. In

both task and reward epochs, for the same mSTS neurons, activity during live competition (face to face or separate rooms) was higher than during replay or decoy condition. Straight diagonal line: firing rate in face to face live = firing rate in other conditions.

Figure 6. Inactivation of mSTS negatively impacted goalie but not kicker performance. **a-b:** Muscimol inactivation of mSTS did not create significant side biases in kicker (**a**) or goalie (**b**). **c:** Muscimol impaired goalies' but not kickers' ability to match the number of redirections made by opponents. **d:** Trial-by-trial cross correlations between kicker's and goalie's total number of moves. Error bars, mean ± SEM. **e:** Muscimol specifically diminished goalies' ability to match opponent redirections as more rounds were played.

Supplementary Videos

Video 1. 10 consecutive recorded trials of a human kicker playing against a human goalie. X axis, horizontal axis on screen (normalized); Y axis, vertical axis on screen (normalized). White line, finish line; green circle, kicker eye position; magenta circle, goalie eye position.

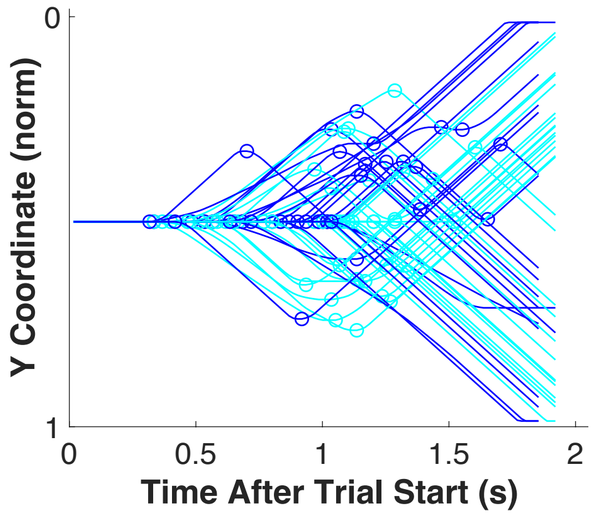
Video 2. 10 consecutive recorded trials of a monkey kicker playing against a monkey goalie. X axis, horizontal axis on and off screen (normalized); Y axis, vertical axis on screen (normalized). White line, finish line; green circle, kicker eye position; magenta circle, goalie eye position. Green rectangle indicates physical location of kicker; magenta rectangle indicates physical location of goalie.

Video 3. Simultaneous video recordings of a monkey kicker playing against a monkey goalie. Left frame: Kicker (monkey L) with goalie's monitor; right: goalie (monkey B) with kicker's monitor.

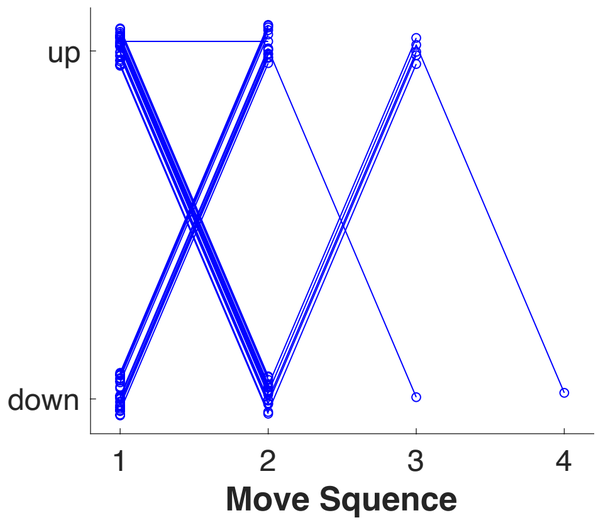
Video 4. A video recording of a monkey kicker playing against a monkey goalie in the horizontal screen setup. Monkey L (left) was the kicker; monkey B (right) was the goalie. Target monkey was B.

S1

a



b



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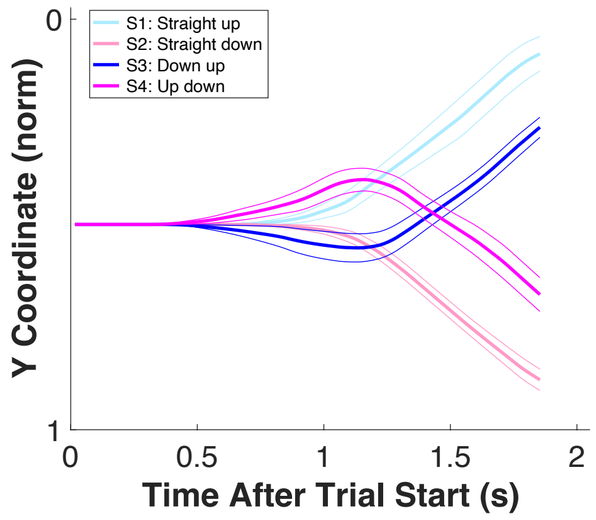

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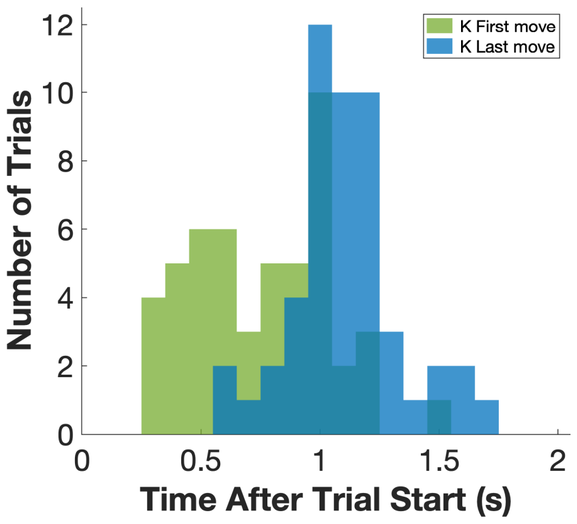

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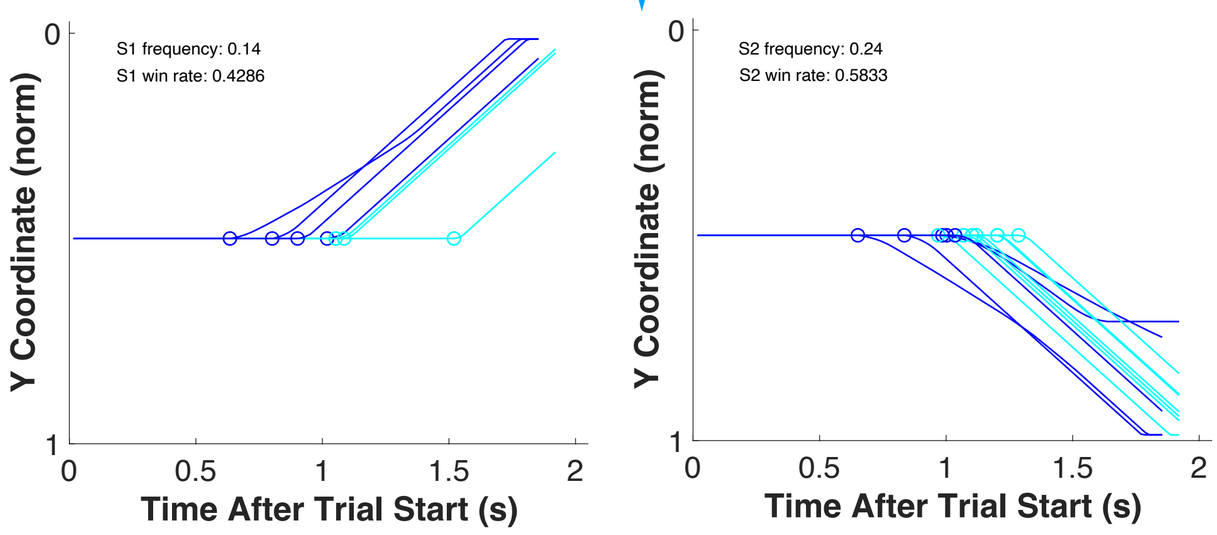
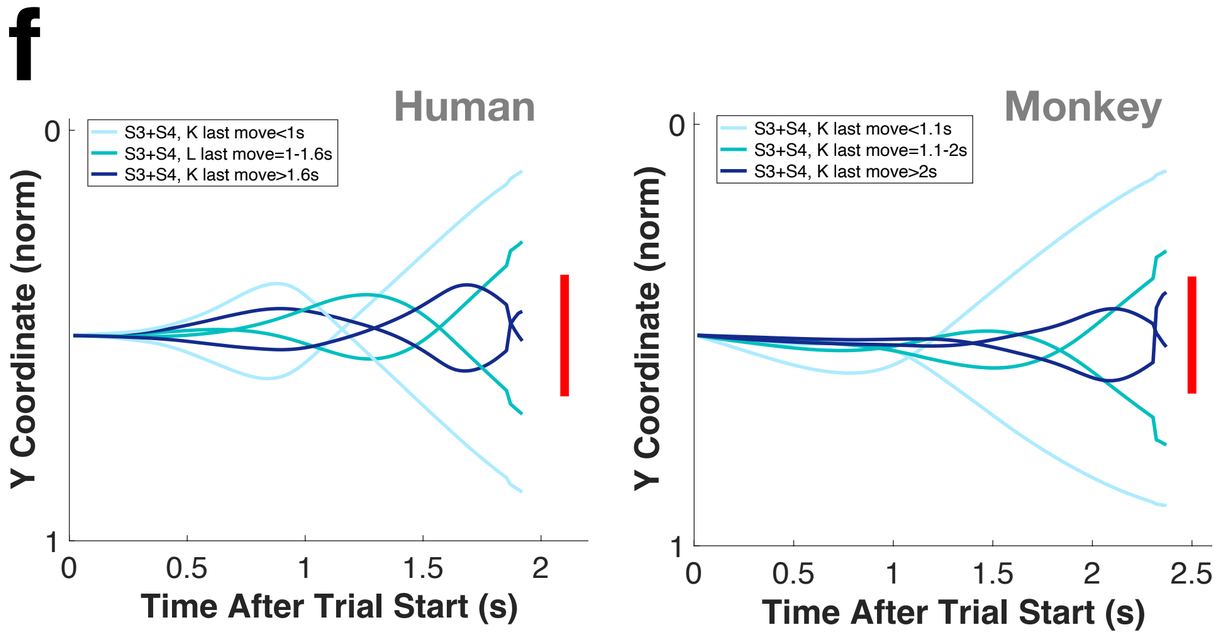


f



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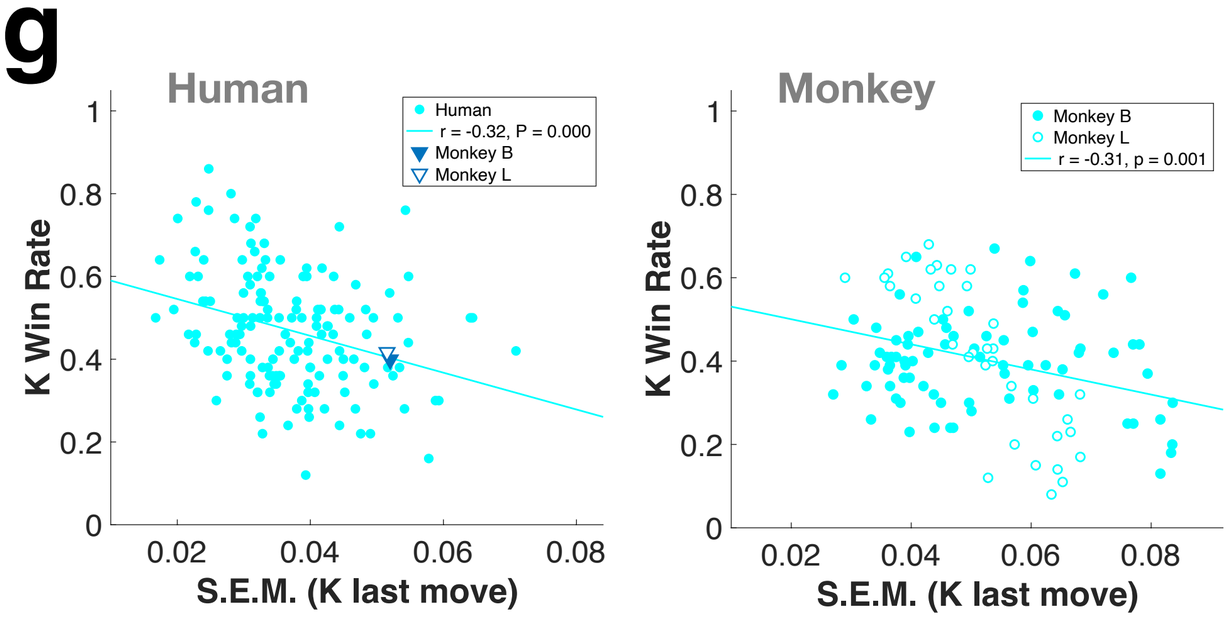

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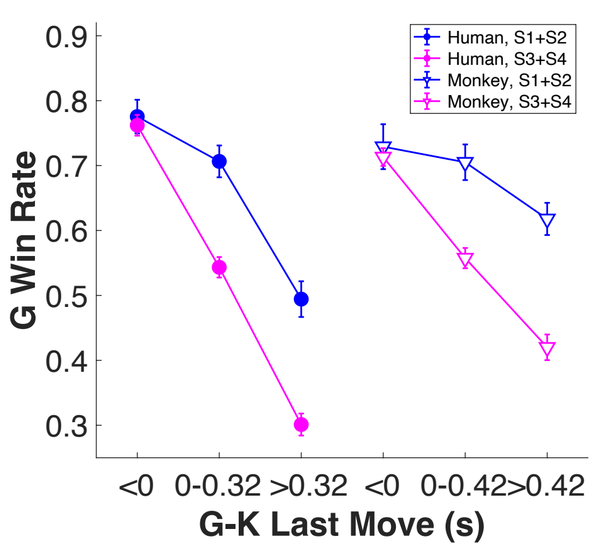
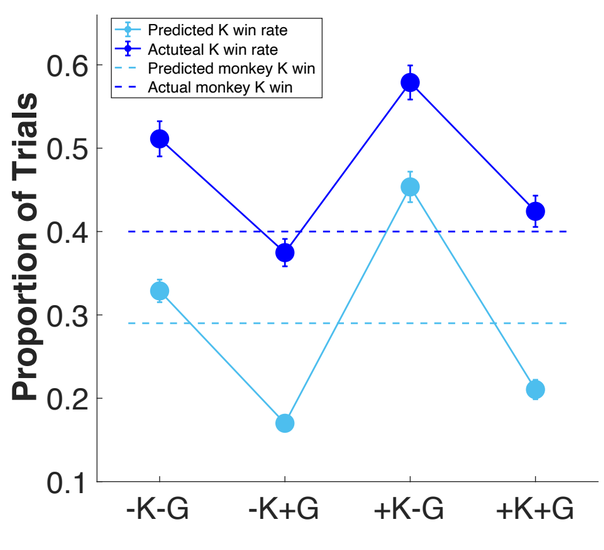


i



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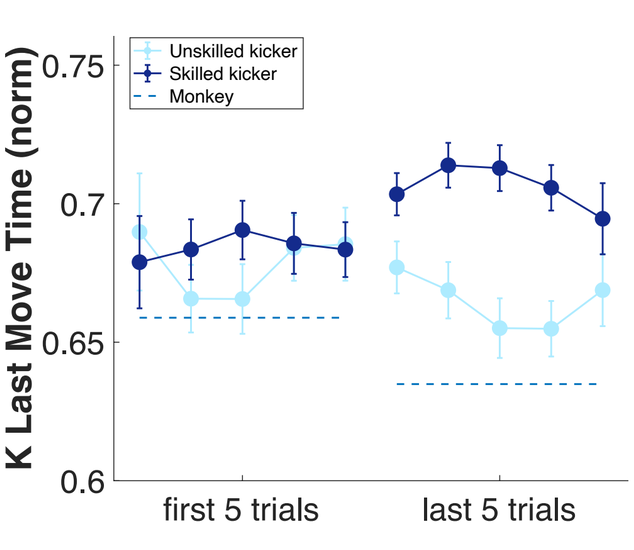
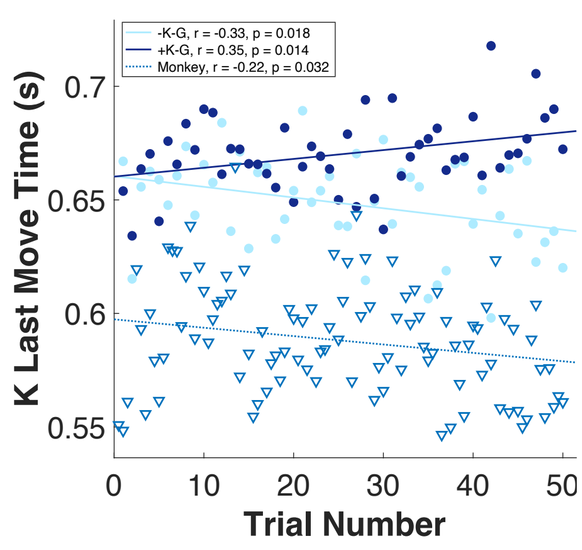
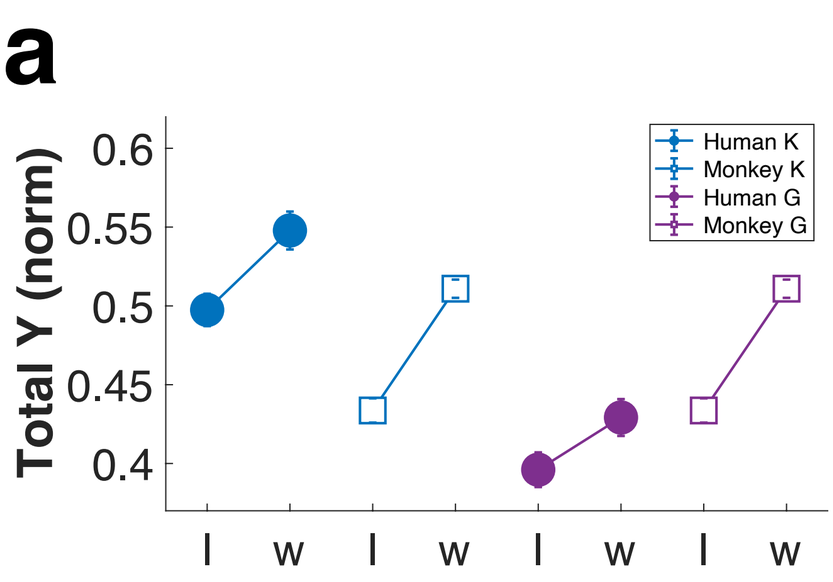
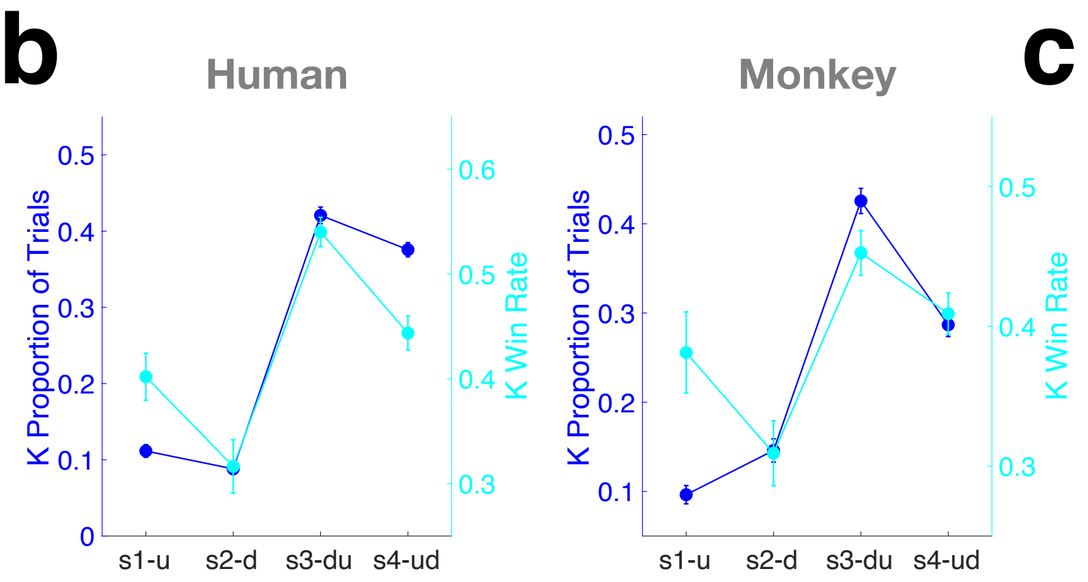
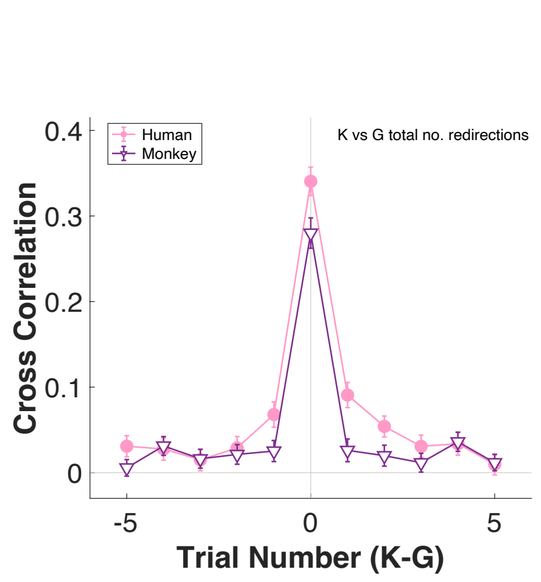


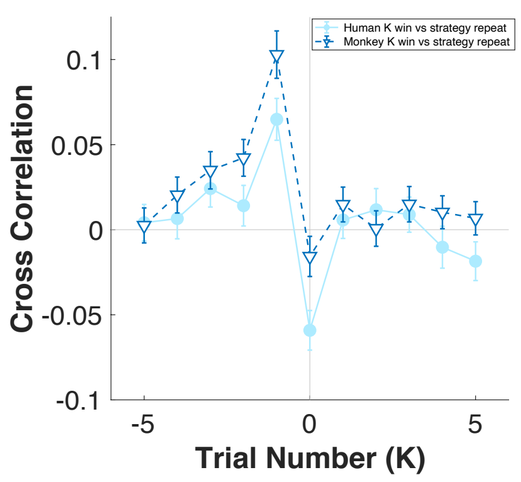


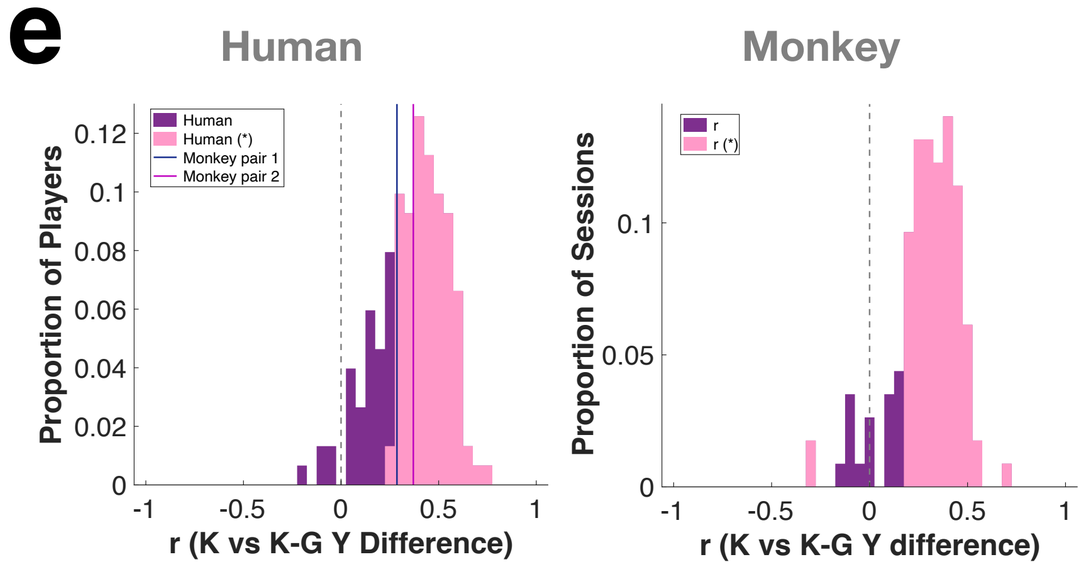
S2

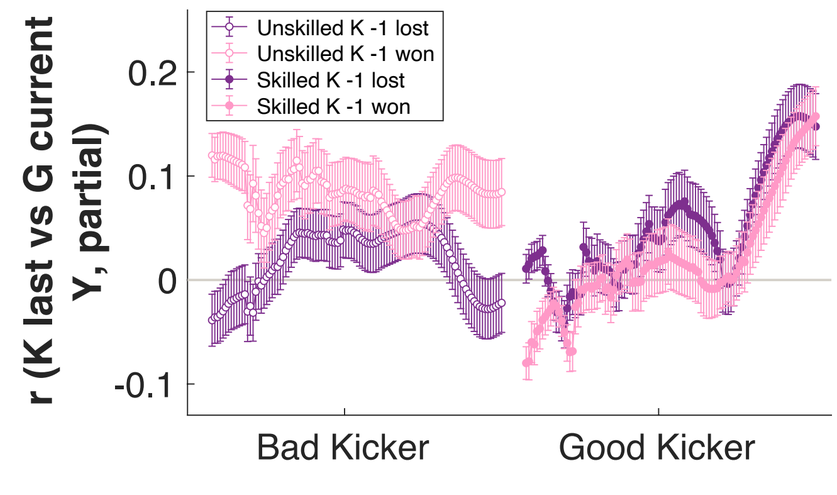

a
Total Y (norm)
0.6
0.55
0.5
0.45
0.4
Human K
Monkey K
Human G
Monkey G
l
w
l
w
l
w
l
w

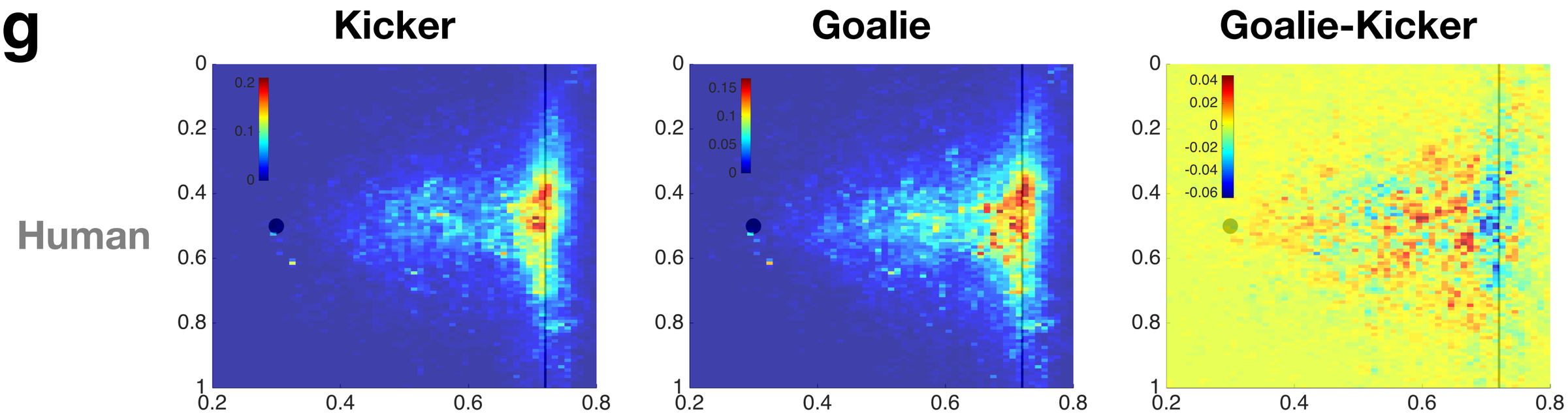

b
Human
Monkey
K Proportion of Trials
K Win Rate
s1-u
s2-d
s3-du
s4-ud

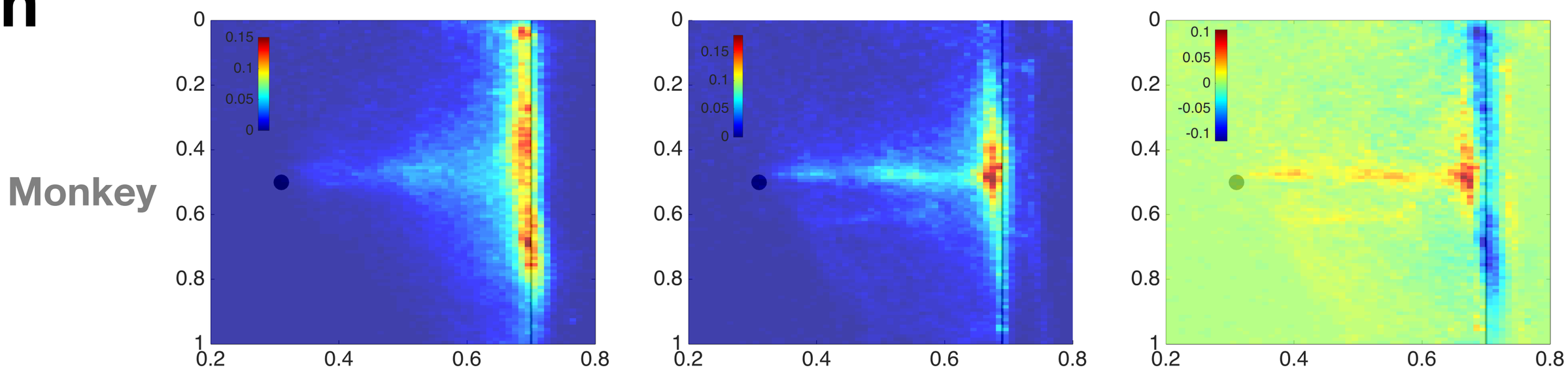

c
K vs G total no. redirections
Human
Monkey
Cross Correlation
Trial Number (K-G)


d
Human K win vs strategy repeat
Monkey K win vs strategy repeat
Cross Correlation
Trial Number (K)

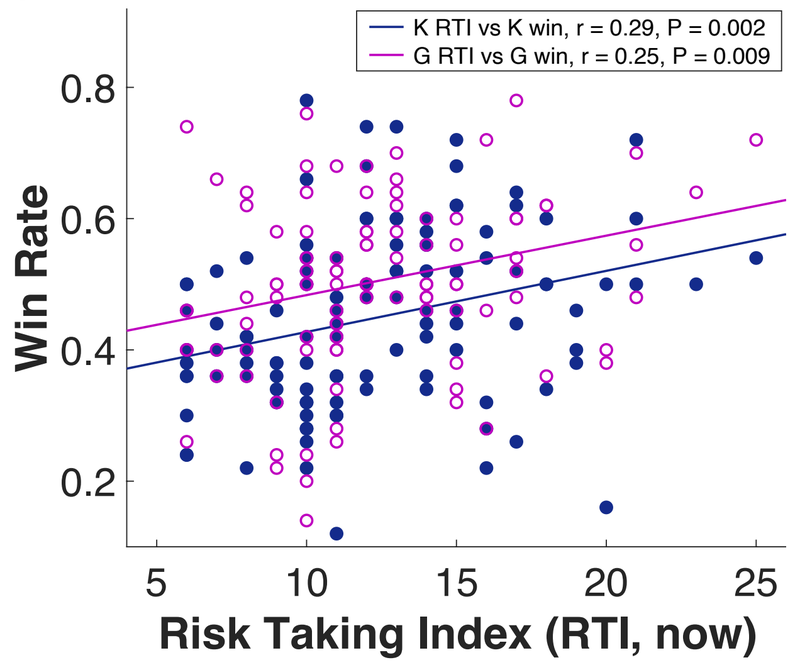

e
Human
Monkey
Human
Human (*)
Monkey pair 1
Monkey pair 2
Proportion of Players
r (K vs K-G Y Difference)
r
r (*)
Proportion of Sessions
r (K vs K-G Y difference)

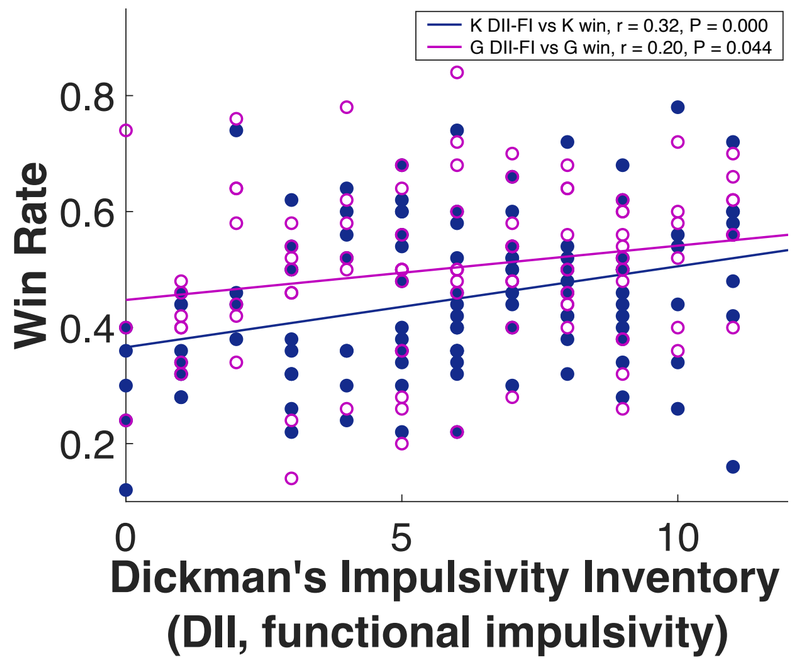

f
Unskilled K -1 lost
Unskilled K -1 won
Skilled K -1 lost
Skilled K -1 won
r (K last vs G current Y, partial)
Bad Kicker
Good Kicker

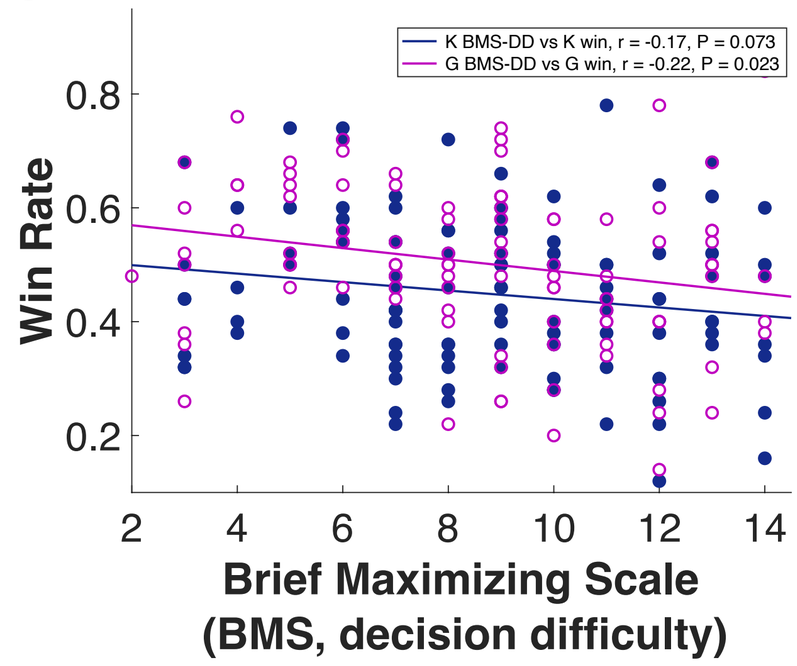

g
Kicker
Goalie
Goalie-Kicker
Human

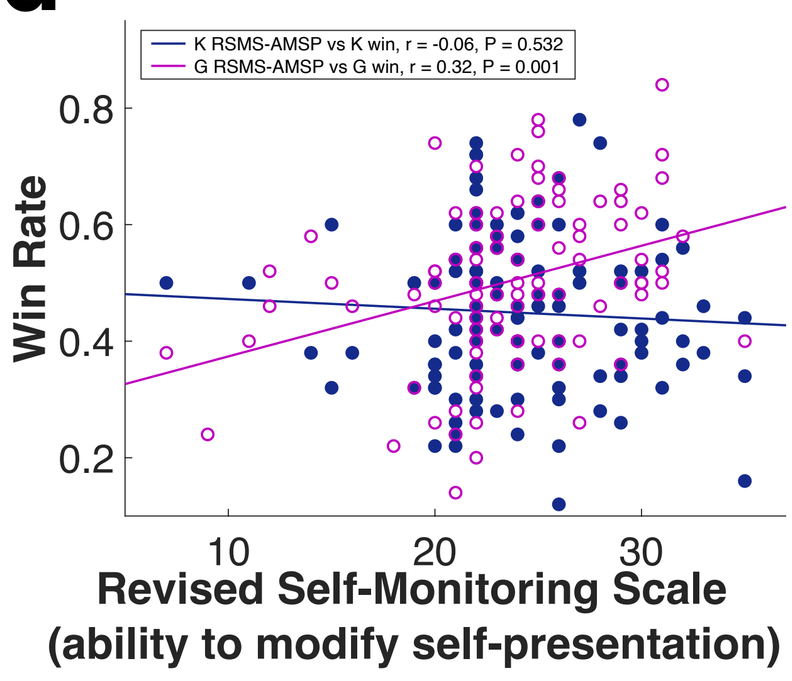

h
Monkey

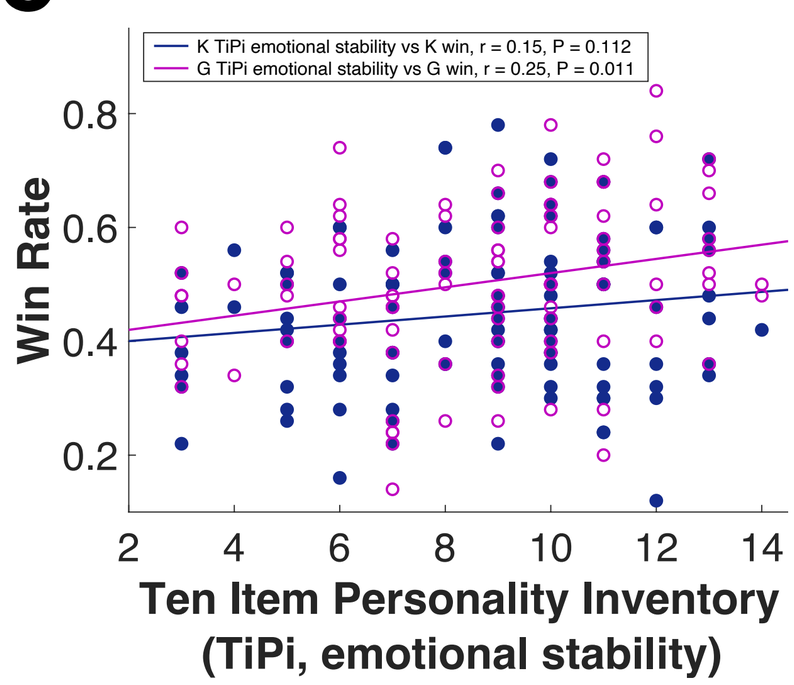
S3

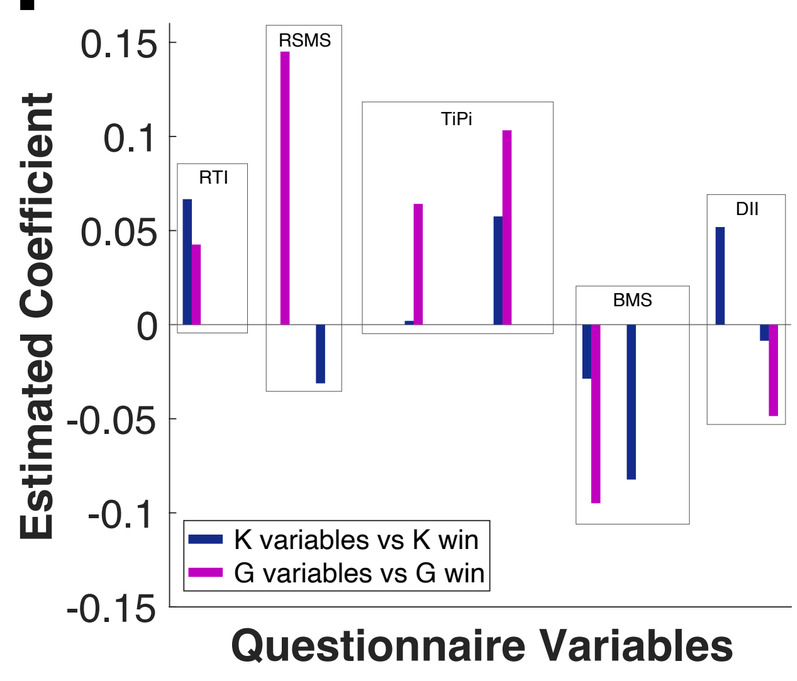

a
K RTI vs K win, r = 0.29, P = 0.002
G RTI vs G win, r = 0.25, P = 0.009
Win Rate
Risk Taking Index (RTI, now)

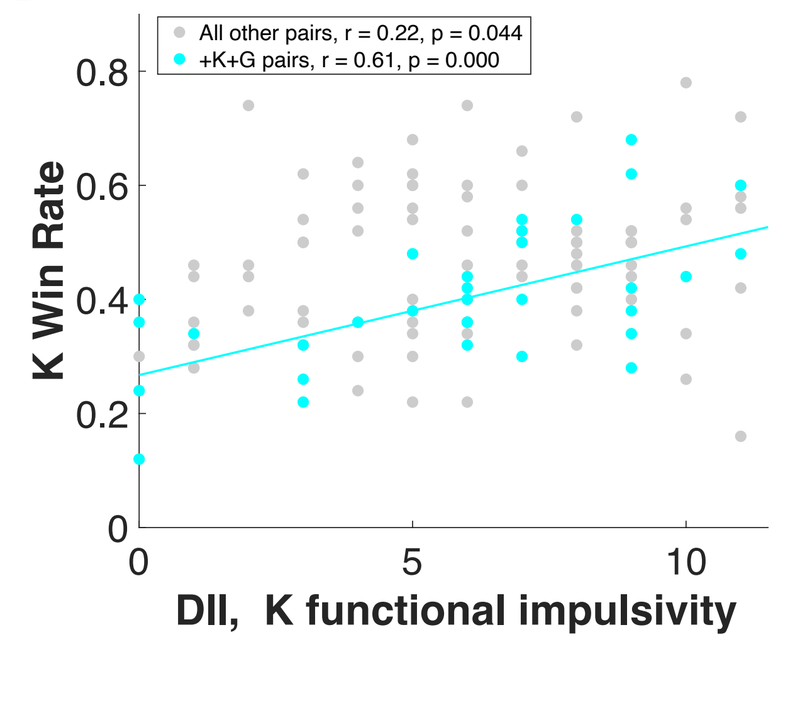

b
K DII-FI vs K win, r = 0.32, P = 0.000
G DII-FI vs G win, r = 0.20, P = 0.044
Win Rate
Dickman's Impulsivity Inventory
(DII, functional impulsivity)

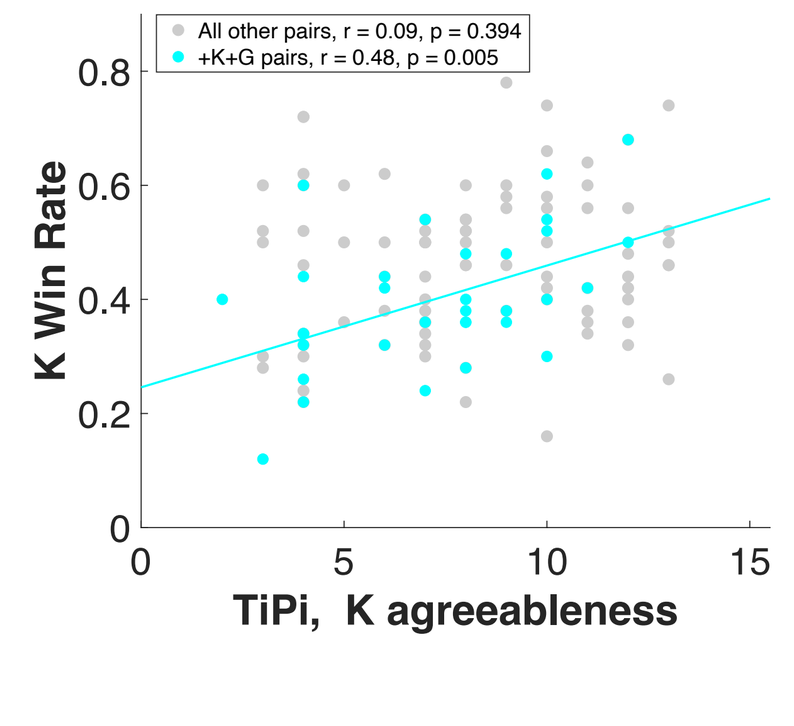

c
K BMS-DD vs K win, r = -0.17, P = 0.073
G BMS-DD vs G win, r = -0.22, P = 0.023
Win Rate
Brief Maximizing Scale
(BMS, decision difficulty)

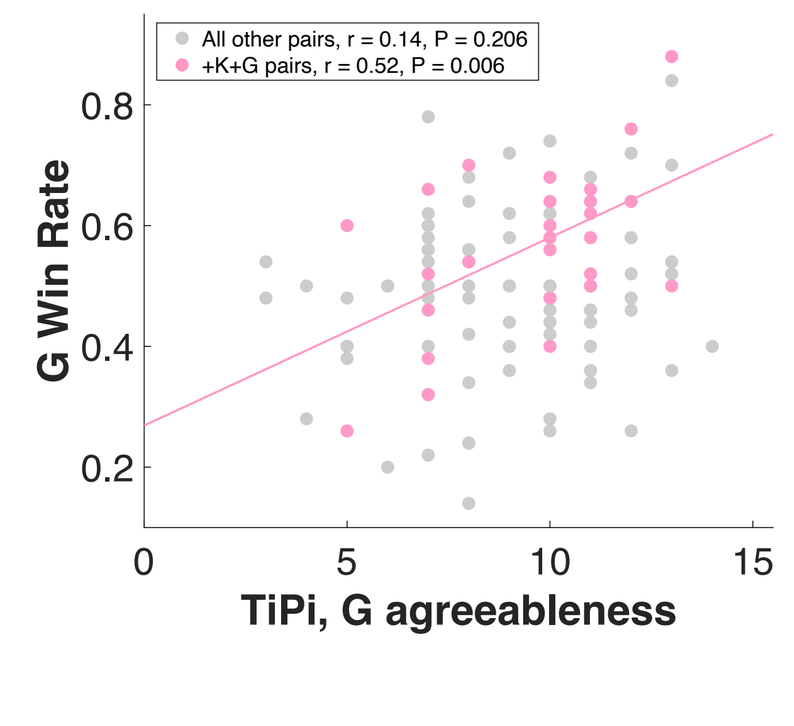

d
K RSMS-AMSP vs K win, r = -0.06, P = 0.532
G RSMS-AMSP vs G win, r = 0.32, P = 0.001
Win Rate
Revised Self-Monitoring Scale
(ability to modify self-presentation)


e
K TiPi emotional stability vs K win, r = 0.15, P = 0.112
G TiPi emotional stability vs G win, r = 0.25, P = 0.011
Win Rate
Ten Item Personality Inventory
(TiPi, emotional stability)


f
RTI
RSMS
TiPi
BMS
DII
K variables vs K win
G variables vs G win
Estimated Coefficient
Questionnaire Variables


g
All other pairs, r = 0.22, p = 0.044
+K+G pairs, r = 0.61, p = 0.000
K Win Rate
DII, K functional impulsivity


h
All other pairs, r = 0.09, p = 0.394
+K+G pairs, r = 0.48, p = 0.005
K Win Rate
TiPi, K agreeableness


i
All other pairs, r = 0.14, P = 0.206
+K+G pairs, r = 0.52, P = 0.006
G Win Rate
TiPi, G agreeableness

table

t1

Kwin	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Kicker	0.07	—	—	-0.03	—	0.01	—	0.06	—	-0.03	-0.08	—	0.05	-0.01
Goalie	0.04	—	0.15	—	—	0.06	—	0.10	—	-0.09	—	—	—	-0.05

t2

K no red	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Kicker	0.10	0.01	—	—	—	—	—	—	—	—	-0.02	—	0.13	—

K last move time	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Kicker	-0.04	—	—	—	—	—	0.06	—	—	—	—	0.04	-0.12	—

K last move optimal	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Kicker	—	—	—	0.10	—	—	—	—	—	—	—	—	-0.11	-0.01

t3

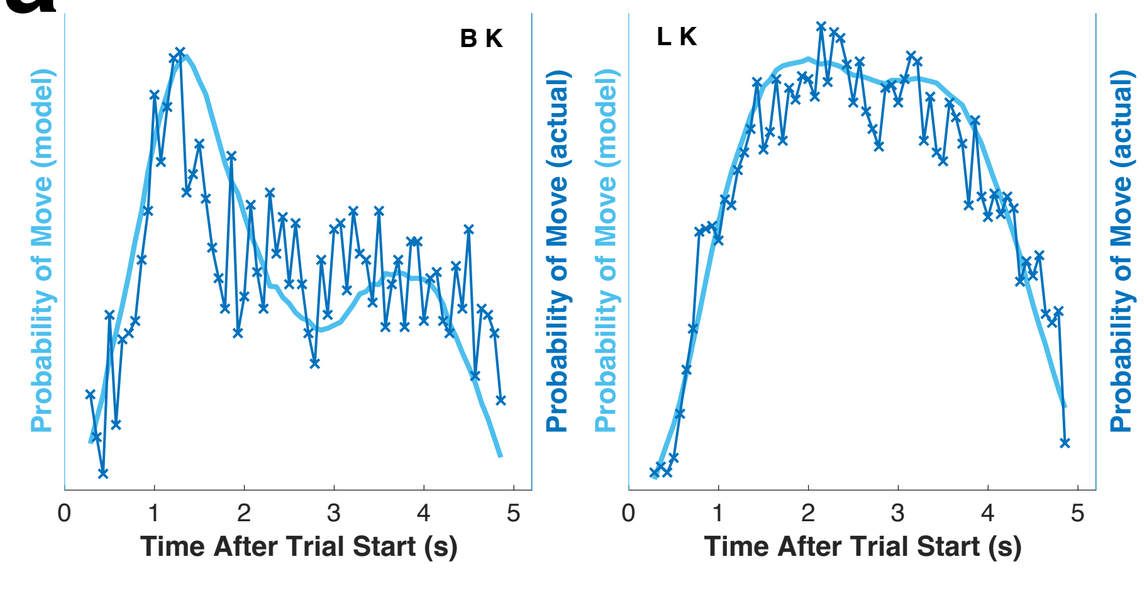
G no red	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Goalie	—	—	—	—	-0.04	—	-0.05	—	—	—	—	—	—	—

G RT	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Goalie	—	—	—	—	—	-0.10	—	—	-0.01	—	—	-0.01	-0.10	—

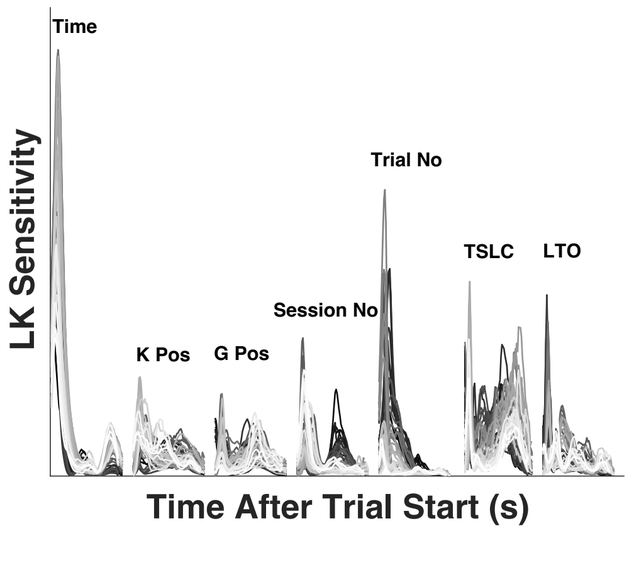
G match K %	RTI		RSMS		TiPi					BMS			DII	
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14
Goalie	—	—	—	—	—	—	—	0.01	—	-0.21	-0.02	0.22	-0.01	-0.02

S4

a



b



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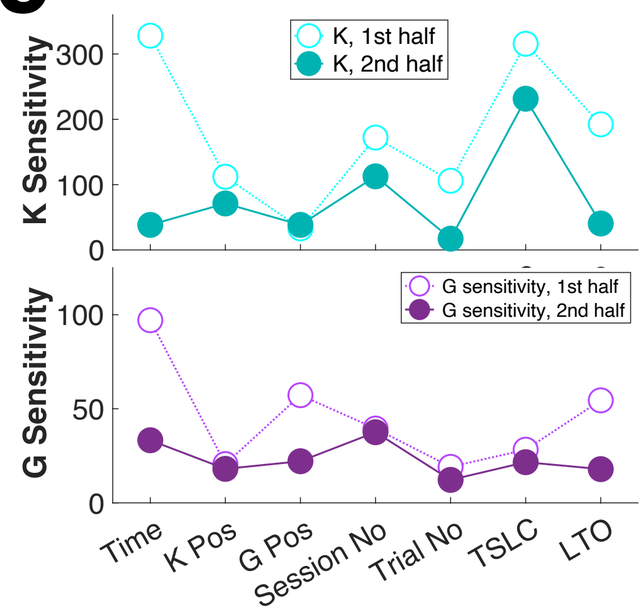
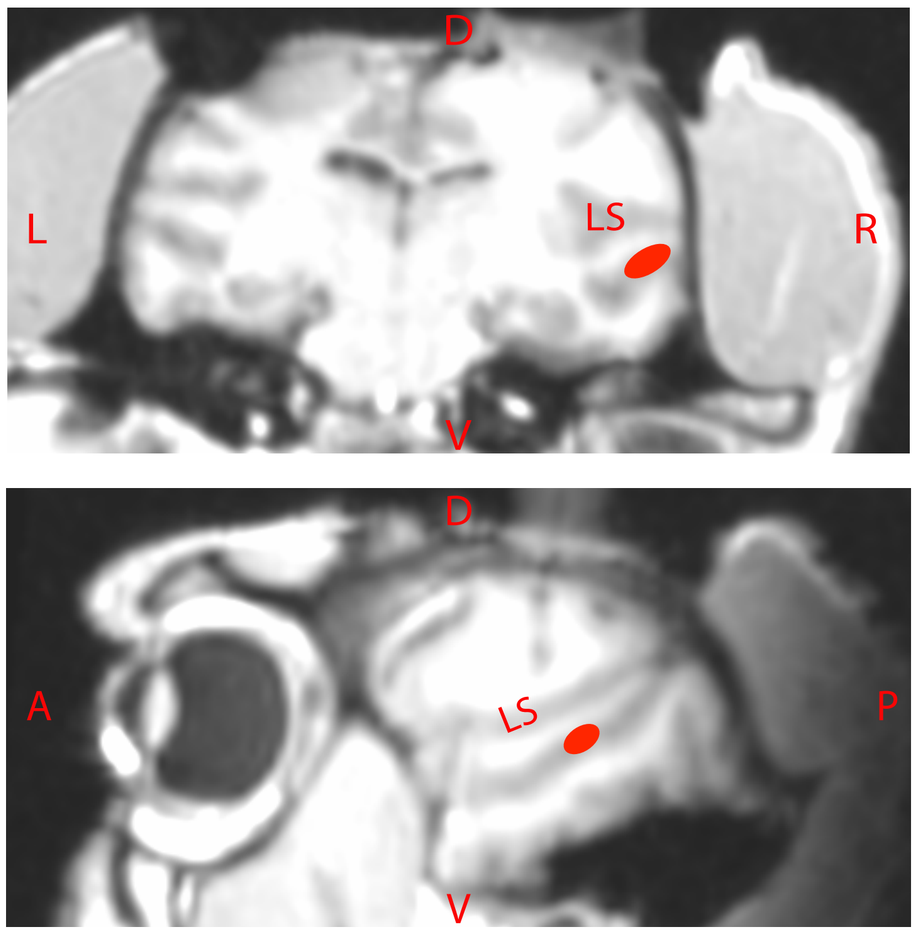
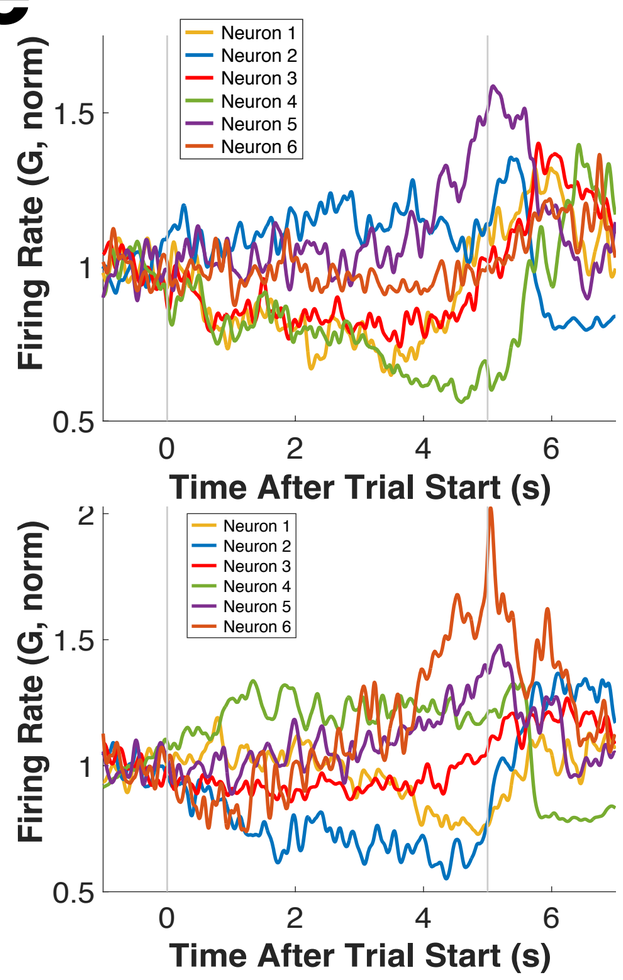


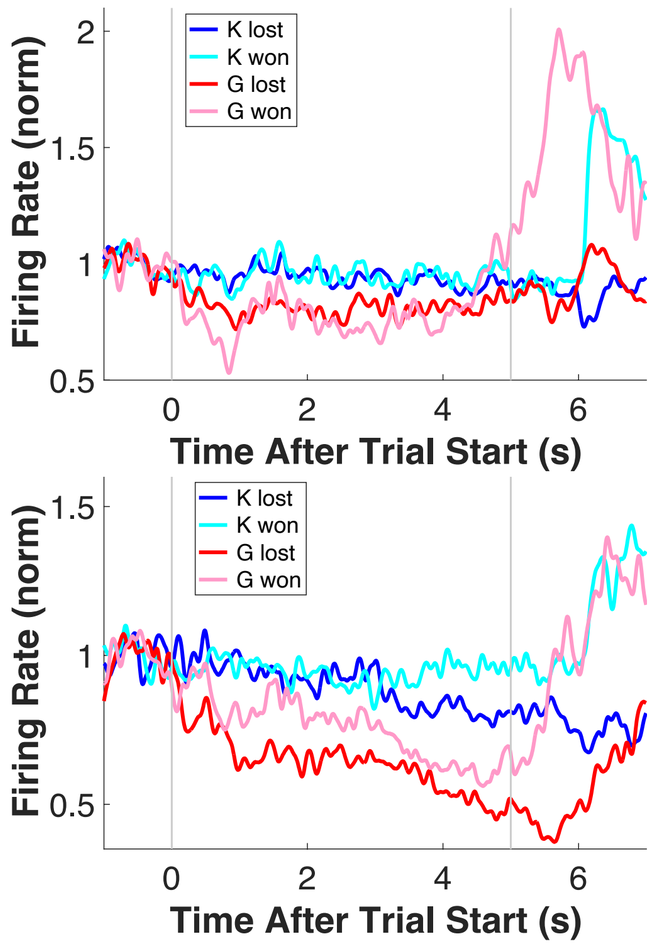
d



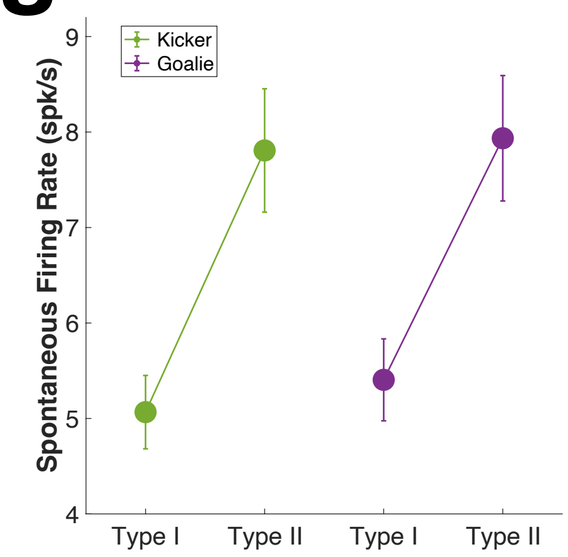
e



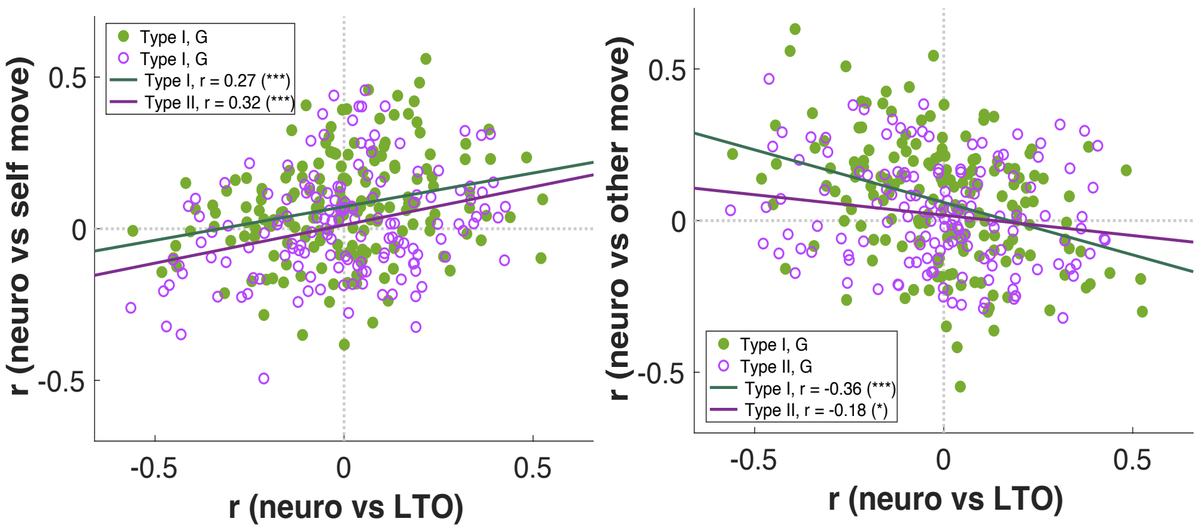
f



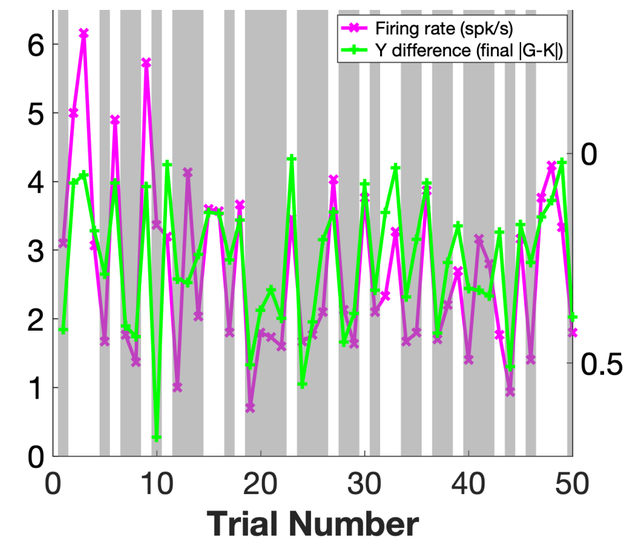
g

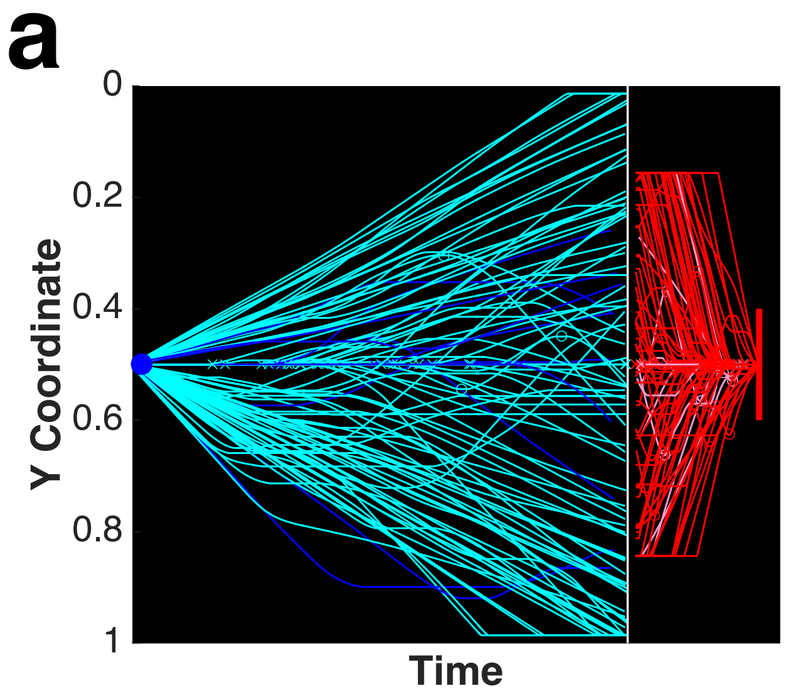


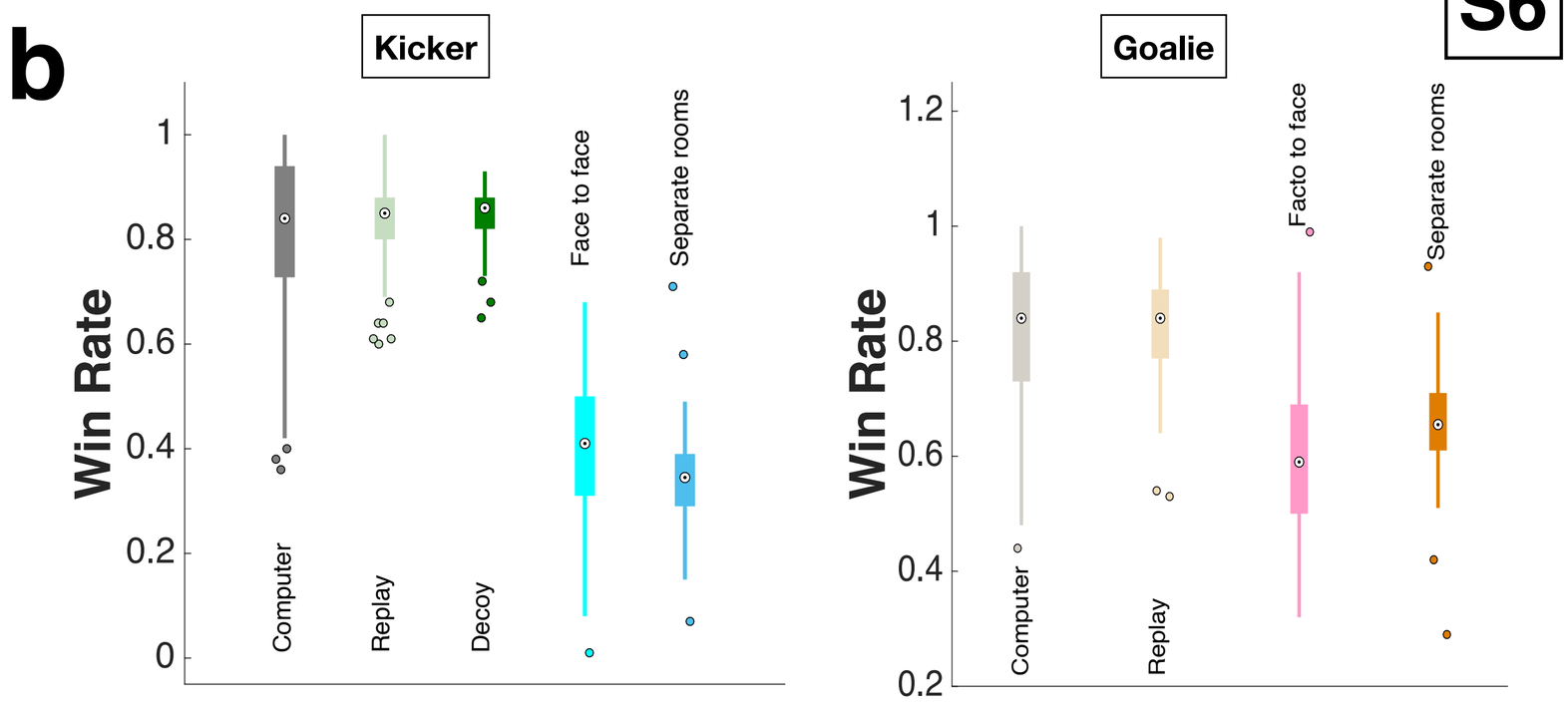
h

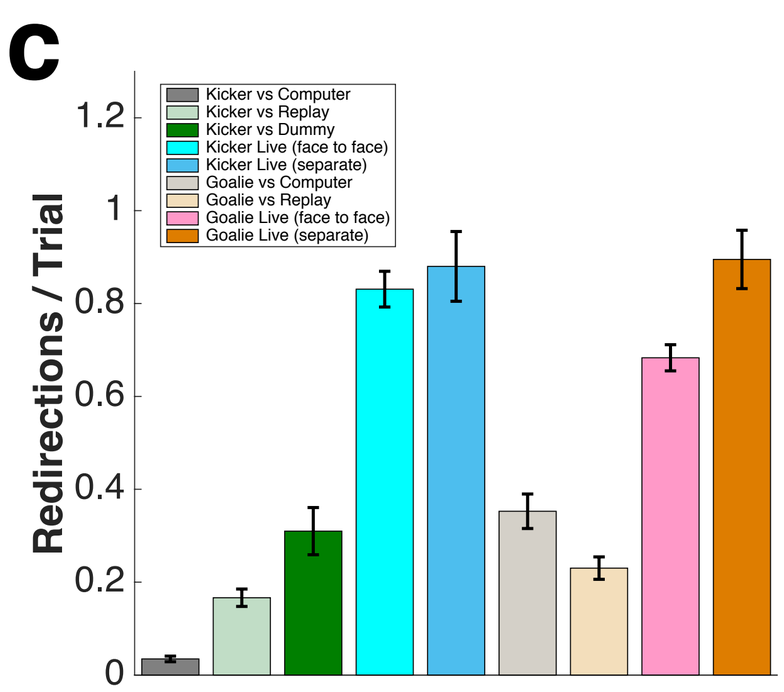


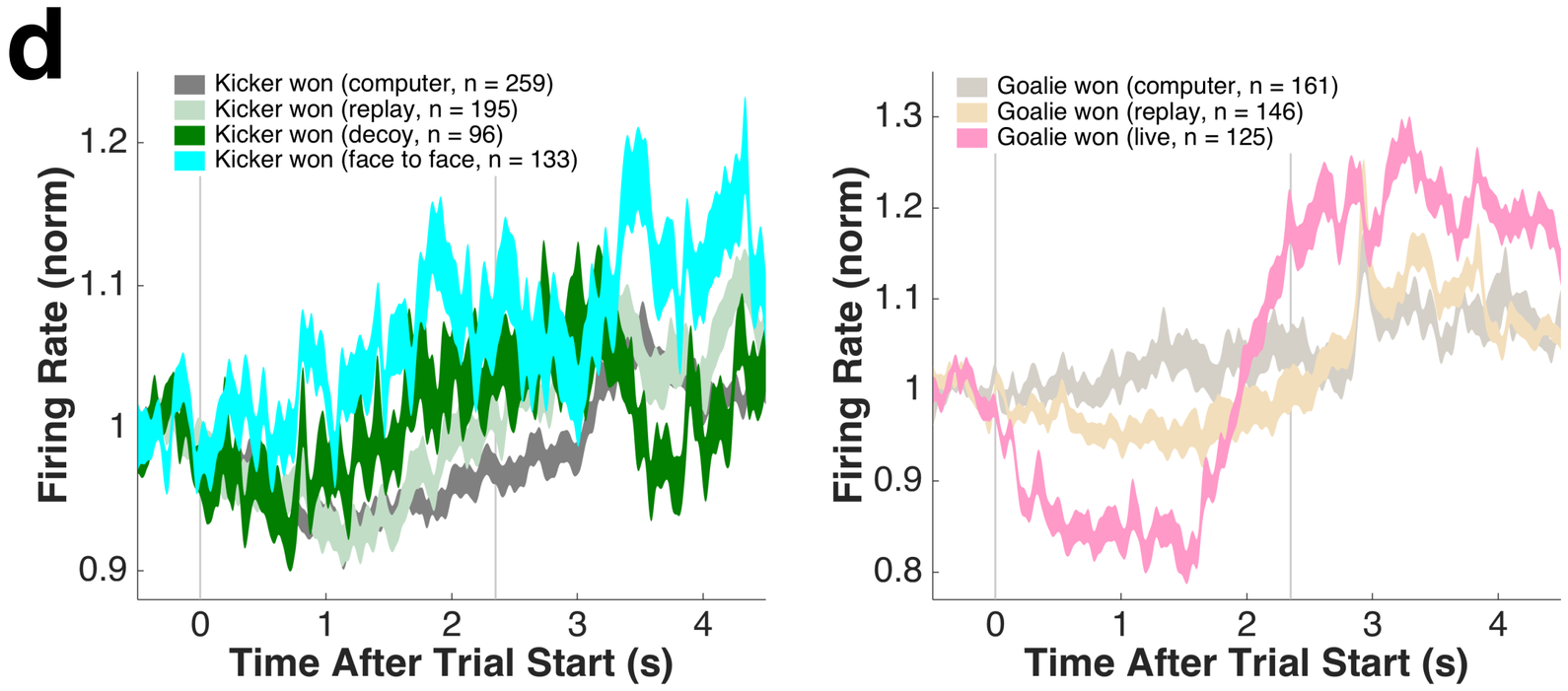
i

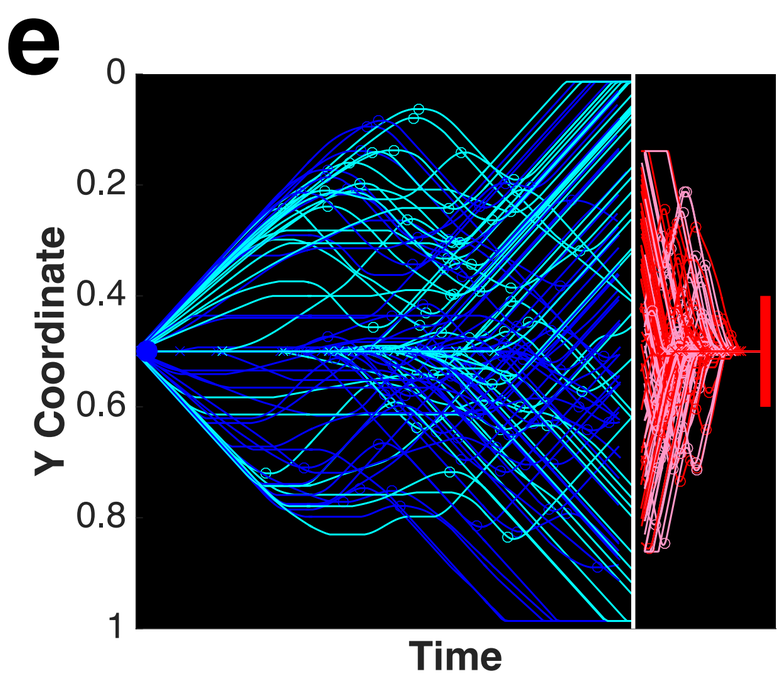


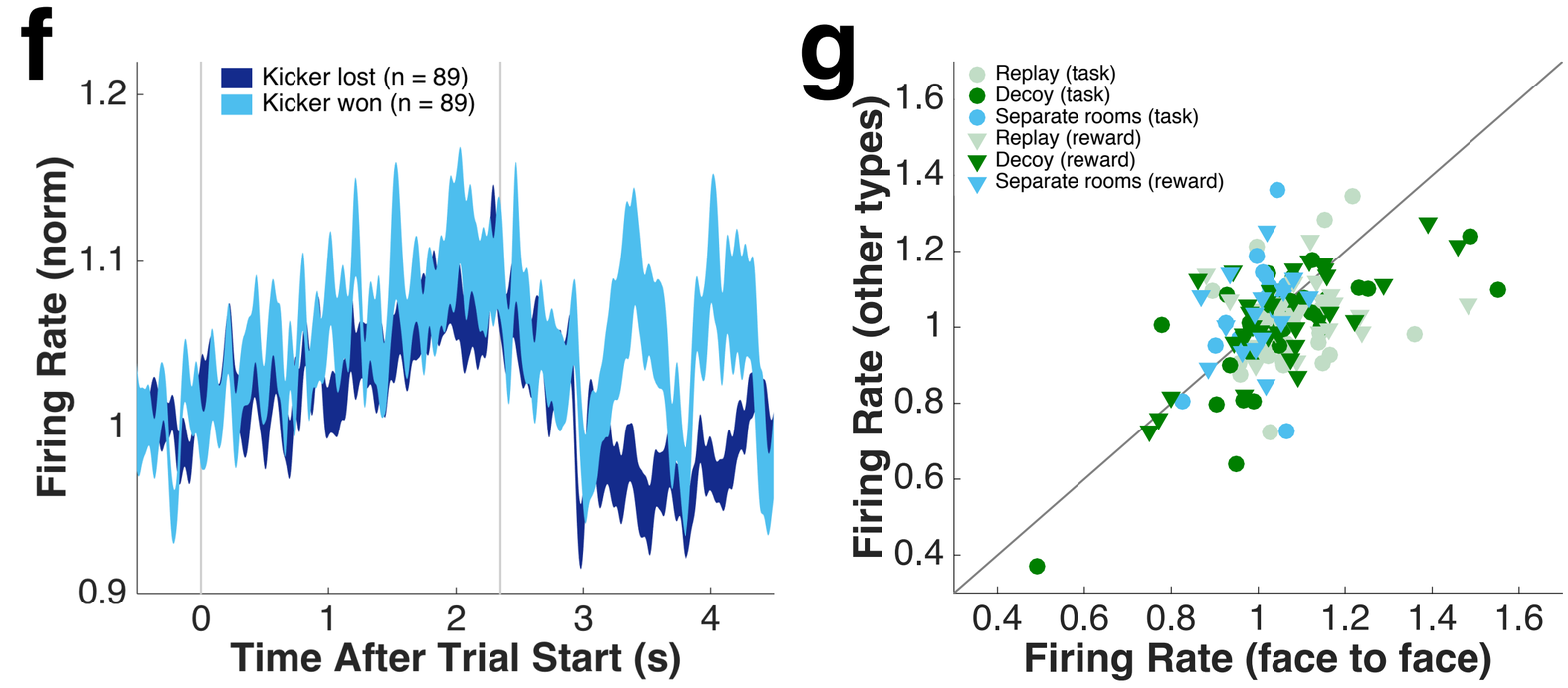

a
Y Coordinate
Time
0
0.2
0.4
0.6
0.8
1


b
Kicker
Goalie
Win Rate
Computer
Replay
Decoy
Face to face
Separate rooms
Facto to face


c
Redirections / Trial
Kicker vs Computer
Kicker vs Replay
Kicker vs Dummy
Kicker Live (face to face)
Kicker Live (separate)
Goalie vs Computer
Goalie vs Replay
Goalie Live (face to face)
Goalie Live (separate)


d
Kicker won (computer, n = 259)
Kicker won (replay, n = 195)
Kicker won (decoy, n = 96)
Kicker won (face to face, n = 133)
Goalie won (computer, n = 161)
Goalie won (replay, n = 146)
Goalie won (live, n = 125)
Firing Rate (norm)
Time After Trial Start (s)

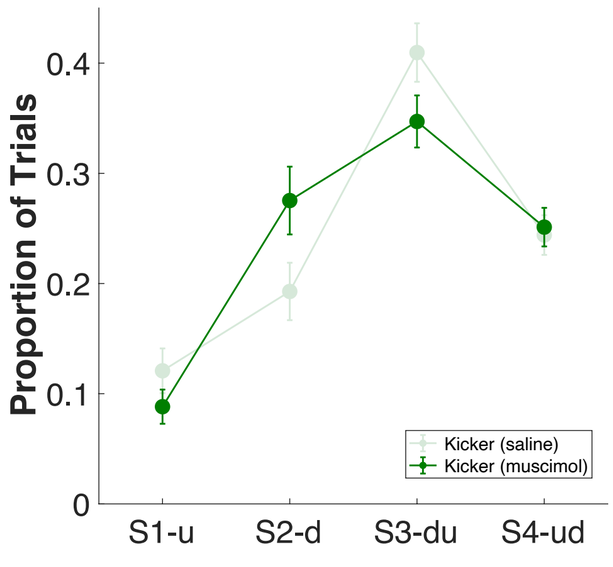

e
Y Coordinate
Time

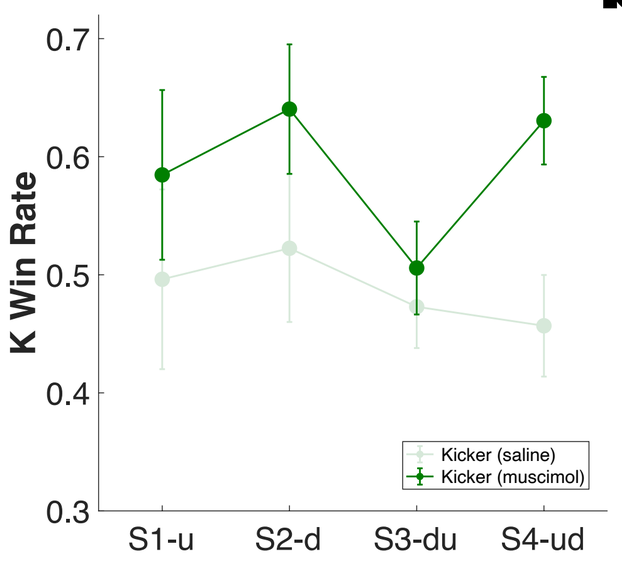

f
Kicker lost (n = 89)
Kicker won (n = 89)
Firing Rate (norm)
Time After Trial Start (s)

g
Replay (task)
Decoy (task)
Separate rooms (task)
Replay (reward)
Decoy (reward)
Separate rooms (reward)
Firing Rate (other types)
Firing Rate (face to face)

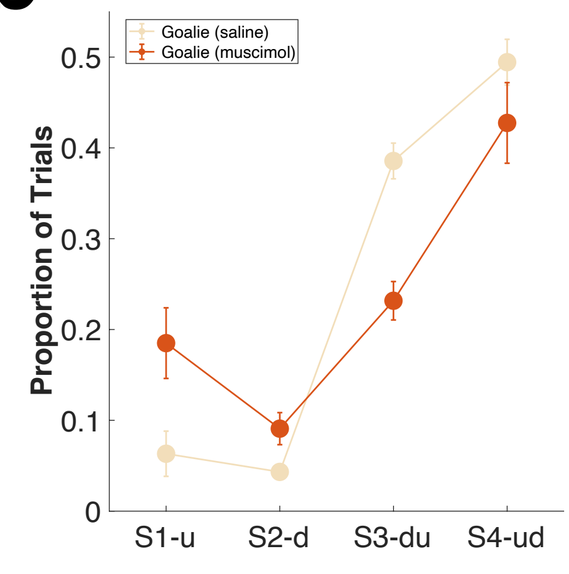
S6

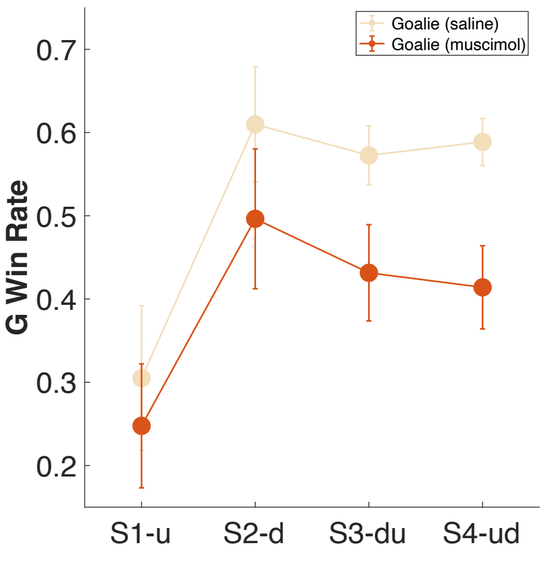
a


Proportion of Trials
0
0.1
0.2
0.3
0.4
S1-u
S2-d
S3-du
S4-ud
Kicker (saline)
Kicker (muscimol)

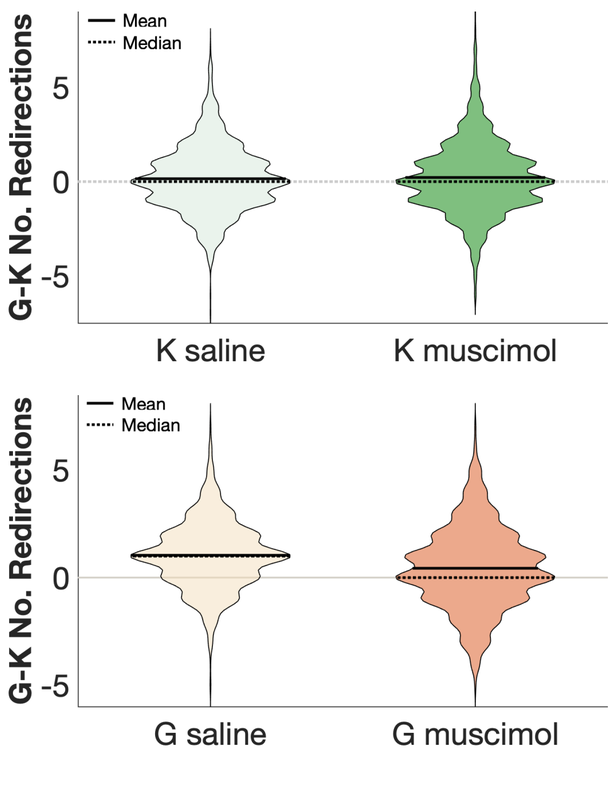

K Win Rate
0.3
0.4
0.5
0.6
0.7
S1-u
S2-d
S3-du
S4-ud
Kicker (saline)
Kicker (muscimol)

b

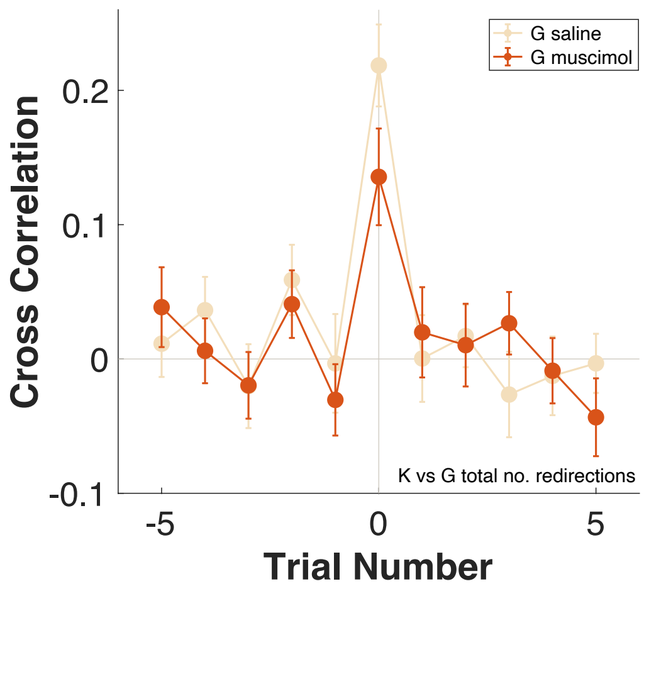

Proportion of Trials
0
0.1
0.2
0.3
0.4
0.5
S1-u
S2-d
S3-du
S4-ud
Goalie (saline)
Goalie (muscimol)


G Win Rate
0.2
0.3
0.4
0.5
0.6
0.7
S1-u
S2-d
S3-du
S4-ud
Goalie (saline)
Goalie (muscimol)

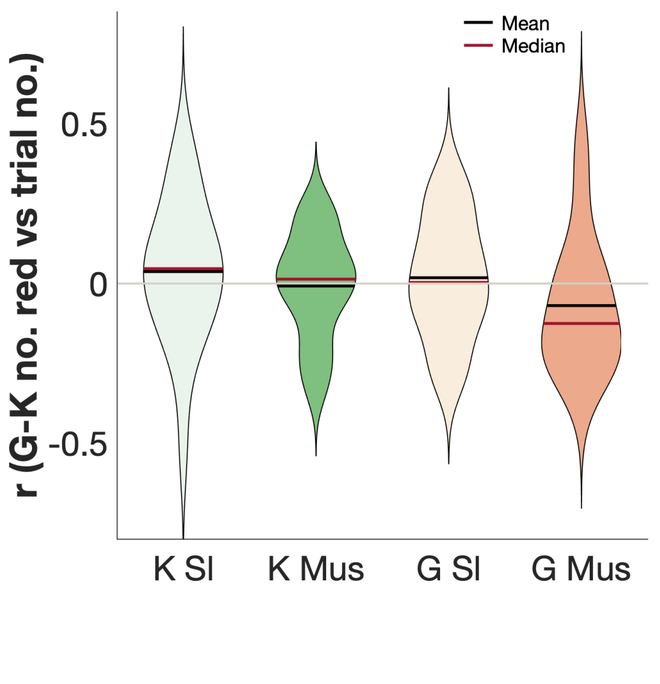
c


G-K No. Redirections
5
0
-5
Mean
Median
K saline
K muscimol
G-K No. Redirections
5
0
-5
Mean
Median
G saline
G muscimol

d


Cross Correlation
-0.1
0
0.1
0.2
-5
0
5
Trial Number
G saline
G muscimol
K vs G total no. redirections

e


r (G-K no. red vs trial no.)
-0.5
0
0.5
Mean
Median
K Sl
K Mus
G Sl
G Mus