Checklist

1. For all authors...
   (a) Do the main claims made in the abstract and introduction accurately reflect the paper's contributions and scope? [Yes]
   (b) Did you describe the limitations of your work? [Yes] See Section 5.3
   (c) Did you discuss any potential negative societal impacts of your work? [Yes] See Section 5.2
   (d) Have you read the ethics review guidelines and ensured that your paper conforms to them? [Yes]
2. If you are including theoretical results...
   (a) Did you state the full set of assumptions of all theoretical results? [N/A]
   (b) Did you include complete proofs of all theoretical results? [N/A]
3. If you ran experiments...
   (a) Did you include the code, data, and instructions needed to reproduce the main experimental results (either in the supplemental material or as a URL)? [Yes] See supplemental materials.
   (b) Did you specify all the training details (e.g., data splits, hyperparameters, how they were chosen)? [N/A] We did not train new models.
   (c) Did you report error bars (e.g., with respect to the random seed after running experiments multiple times)? [Yes] We reported dispersion measures and test statistics where appropriate. All histograms represent exact counts of the data.
   (d) Did you include the total amount of compute and the type of resources used (e.g., type of GPUs, internal cluster, or cloud provider)? [No] Compute was not significant since we were not training new models.
4. If you are using existing assets (e.g., code, data, models) or curating/releasing new assets...
   (a) If your work uses existing assets, did you cite the creators? [Yes] See Section 3.1
   (b) Did you mention the license of the assets? [Yes] See Section 3.1
   (c) Did you include any new assets either in the supplemental material or as a URL? [N/A]
   (d) Did you discuss whether and how consent was obtained from people whose data you're using/curating? [Yes] See Section 3.1
   (e) Did you discuss whether the data you are using/curating contains personally identifiable information or offensive content? [Yes] See Section 3.1. No PII was collected, and no offensive content was used/shown.
5. If you used crowdsourcing or conducted research with human subjects...
   (a) Did you include the full text of instructions given to participants and screenshots, if applicable? [Yes] See supplemental materials.
   (b) Did you describe any potential participant risks, with links to Institutional Review Board (IRB) approvals, if applicable? [Yes] See Section 3.1. No significant participant risks were expected, no adverse events occurred during the course of the experiment. IRB approval link and institution name removed for anonymous review stage; will be added back for for later stage.
   (c) Did you include the estimated hourly wage paid to participants and the total amount spent on participant compensation? [Yes] See Section 3.1

Supplemental Materials

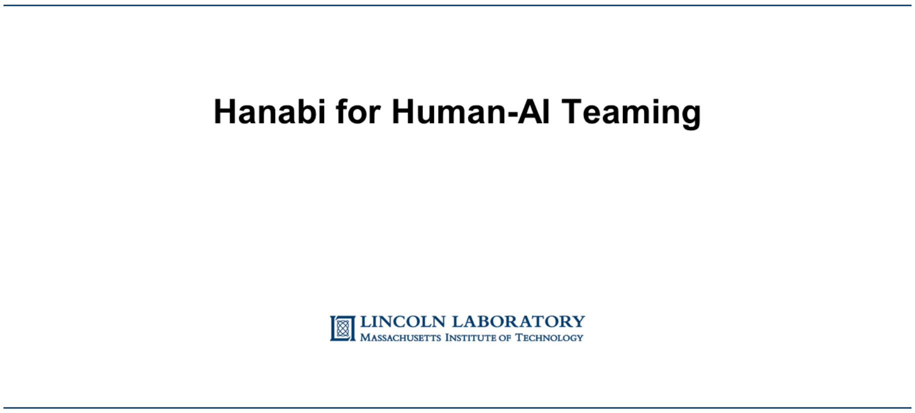
For data transparency and completeness, we detail our participant recruitment process, participant instructions, relevant aggregate data (demographics, scores, surveys), as well as the results from statistical tests that we conducted, but were not part of the main paper due to space constraints. We do not include the results of the NASA Task Load Index survey here because those were not analyzed for this study.

6.1 Participant Recruitment

Participants for this experiment were recruited via convenience and snowball sampling, with initial emails to MIT research groups and social mailing lists, as well as some for other Cambridge-areas groups. We note that 6 out of 29 participants belonged to the *hanab.live* Hanabi gaming community. Other than those, participants were novices to Hanabi, did not play consistently, or came from several distinct and unrelated Hanabi groups.

6.2 Introductory Slides and Game Interface

These are the slides shown to experiment participants at the very beginning of the session. All subjects were shown the same slides.



Hanabi for Human-AI Teaming

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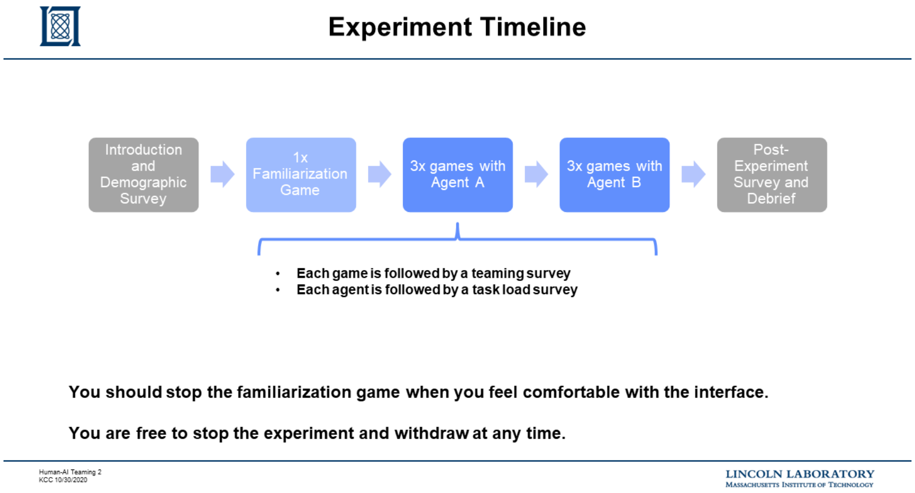

Experiment Timeline

Introduction and Demographic Survey
1x Familiarization Game
3x games with Agent A
3x games with Agent B
Post-Experiment Survey and Debrief

- Each game is followed by a teaming survey
- Each agent is followed by a task load survey

You should stop the familiarization game when you feel comfortable with the interface.

You are free to stop the experiment and withdraw at any time.

Human-AI Teaming 2
KCC 10/30/2020

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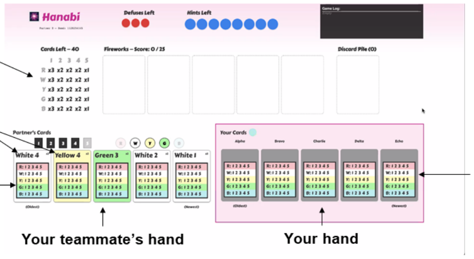
Hanabi Rules and Game Interface

You can see your teammate's cards, but not your own
You can see the hints you have given your teammate, and the hints they have given you



The list of cards in the deck and both hands

The AI's cards

Hints you have given to the AI

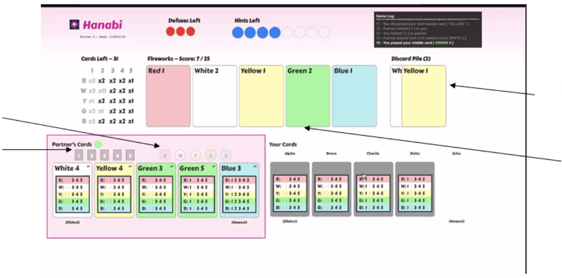
Your teammate's hand

Your hand

Hints the AI has given you

Hanabi Rules and Game Interface

On your turn you can….



Hint a color

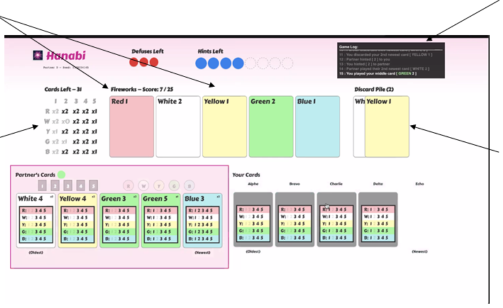
Hint a number

Discard one of your cards

Play one of your cards

Hanabi Rules and Game Interface

The goal is to play 5 cards of each color in ascending order
i.e. Red 1, then Red 2, through Red 5



If a played card is in the correct order it will be in this area

Moves are recorded here

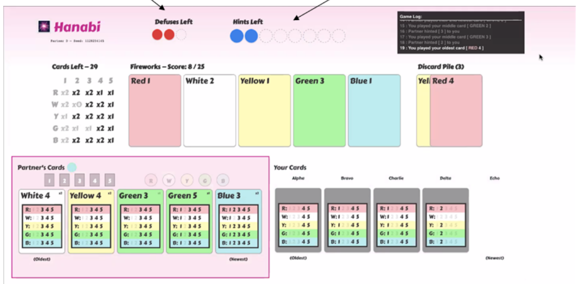
If a card is played in the wrong order or is discarded it will be here

The list of cards in the deck

Hanabi Rules and Game Interface

If a played card is in the wrong order, the defuses left will decrement

If a card is discarded, the hint tokens will increment
If a hint is given, the hint tokens will decrement



Game Log:
15 : You played your middle card [GREEN 2]
16 : Partner hinted [3] to you
17 : You played your middle card [GREEN 3]
18 : Partner hinted [2] to you
19 : You played your oldest card [RED 4]

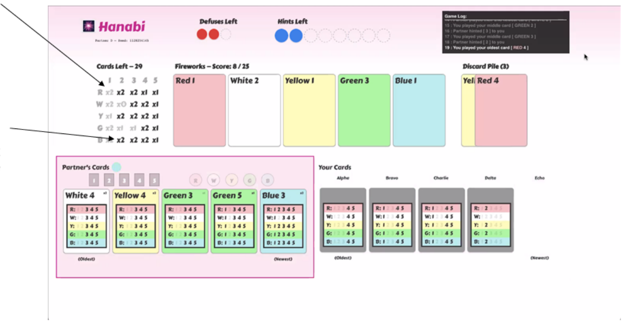
	1	2	3	4	5
R	x2	x2	x2	x1	x1
W	x2	x0	x2	x2	x1
Y	x1	x2	x2	x2	x1
G	x2	x1	x1	x2	x1
B	x2	x2	x2	x2	x1

If there are 8 hint tokens, you must play a card or hint, you can <u>not</u> discard
If there are no hint tokens, you <u>must</u> play a card or discard

Hanabi Rules and Game Interface

Cards that have been played are greyed out

Cards that can still be played are black, and the number indicates how many are not in the discard pile



Game Log:
15 : You played your middle card [GREEN 2]
16 : Partner hinted [3] to you
17 : You played your middle card [GREEN 3]
18 : Partner hinted [2] to you
19 : You played your oldest card [RED 4]

	1	2	3	4	5
R	x2	x2	x2	x1	x1
W	x2	x0	x2	x2	x1
Y	x1	x2	x2	x2	x1
G	x2	x1	x1	x2	x1
B	x2	x2	x2	x2	x1

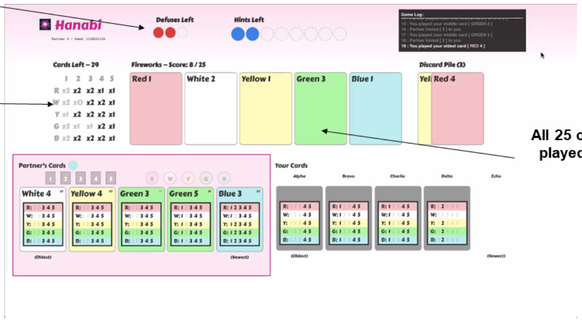
Hanabi Rules and Game Interface

The game ends under one of three conditions

There are no defuses left

After the last card is drawn, each player has one more turn

All 25 cards have been played in the correct order



Game Log:
15 : You played your middle card [GREEN 2]
16 : Partner hinted [3] to you
17 : You played your middle card [GREEN 3]
18 : Partner hinted [2] to you
19 : You played your oldest card [RED 4]

	1	2	3	4	5
R	x2	x2	x2	x1	x1
W	x2	x0	x2	x2	x1
Y	x1	x2	x2	x2	x1
G	x2	x1	x1	x2	x1
B	x2	x2	x2	x2	x1

6.3 Demographic Survey

Questions 1-4 are two pairs of multiple choice and free response questions. Questions 5-10 are Likert scale statements with a scale from 1 (strongly disagree) to 7 (strongly agree). Questions 9 and 10 also include a free response ("Explain") if the participant indicates agreement with the statement.

Table 4: Demographic Survey Prompt and Response Choices

	Prompt	**Response Choices**
D1	How often do you play card or board games?	[Never, <1 hour/week, 1-3 hours/week, >3 hours/week]
D2	Which games or types of games do you play?	free response
D3	How often do you play video games?	[Never, <1 hour/week, 1-3 hours/week, >3 hours/week]
D4	Which game or types of video games do you play?	free response
D5	I am experienced in cooperative card games.	Likert Scale
D6	I am experienced in cooperative board games.	Likert Scale
D7	I am experienced in cooperative video games.	Likert Scale
D8	I am experienced in Hanabi.	Likert Scale
D9	I am experienced in interacting with artificial intelligence agents (including voice assistants, game AIs, etc).	Likert Scale, free response ($optional$)
D10	I am experienced in developing artificial intelligence agents.	Likert Scale, free response ($optional$)

6.4 Demographic Survey Responses

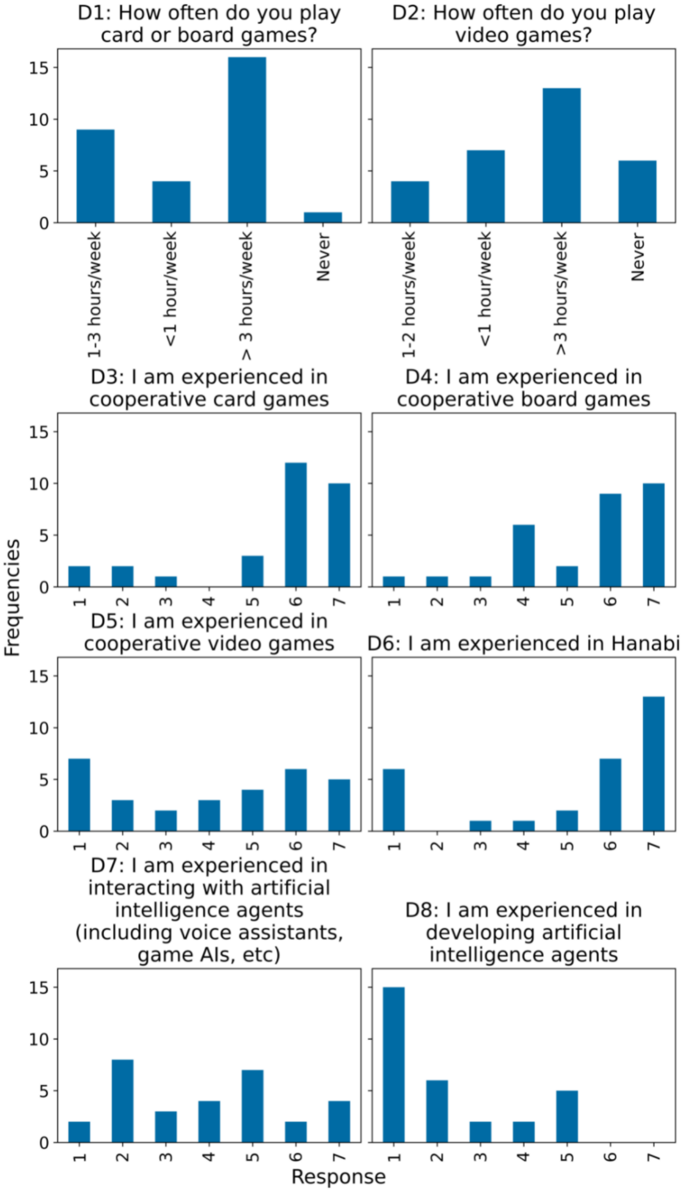


Figure 5: Histograms of all numerical and categorical demographic survey responses.

6.5 Post-Game Likert Scale Question Responses

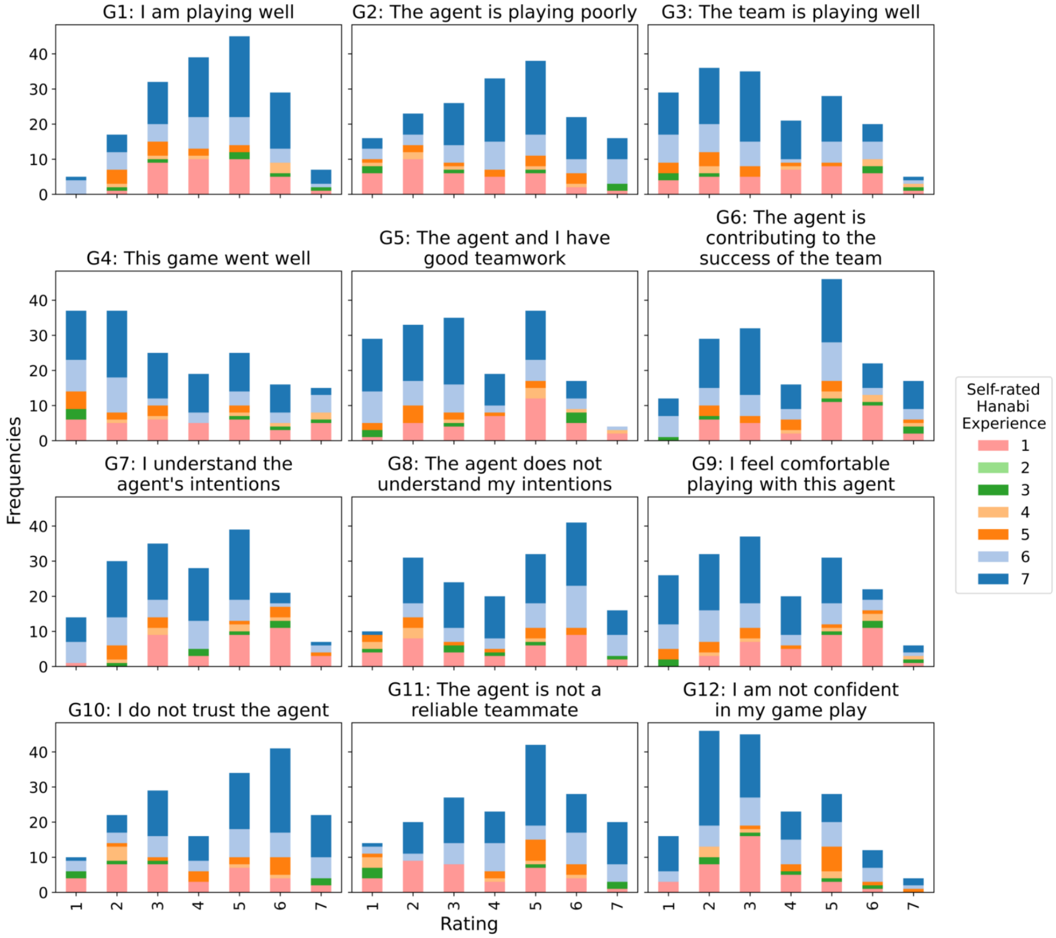


Figure 6: Participant rating for all post-game questions by self-rated Hanabi experience where statistically significant differences related to factors of agent and/or experience were presented in Section 4.2 . The scale ranges from 1-7, corresponding to "strongly disagree" to "strongly agree".

6.6 Participant Scores

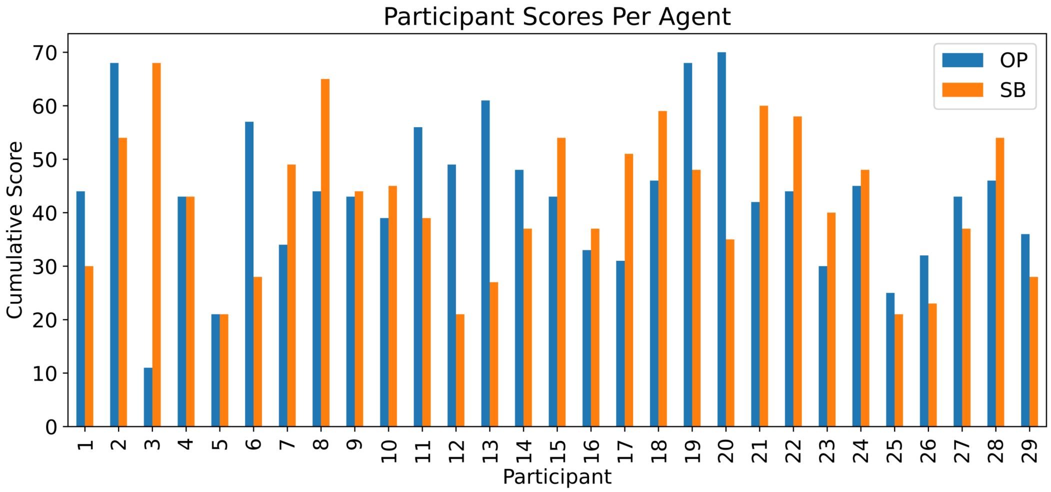


Figure 7: Cumulative game score for each participant across their six games, split by their three games with each agent type. The maximum achievable cumulative score per agent type is 75, and 150 for both. Participant 2 achieved the highest cumulative score of 122.

6.7 Post-Game Survey Statistics

Objective and subjective data were fit to second-order mixed-effects models with fixed factors of (1) AI agent, (2) self-rated Hanabi experience, (3) block (the first or second set of three games), and (4) game number (first, second, or third game within a block), and a random factor of participant number. AI agent and participant number were considered categorical variables.

Agent refers to the AI agent type (OP or SB).

Experience refers to the self-reported Hanabi experience level (question D8).

Lower and *Upper* are the values for the 95% confidence intervals.

Table 5: Model fit to response variable of game score

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.6084	4.2962	0.37438	158	0.70863	-6.877	10.094
Block	5.282	2.0039	2.6358	158	**0.0092295**	1.3241	9.2398
Game	2.9572	1.567	1.8872	158	0.060961	-0.13765	6.0521
Experience	0.7736	0.62989	1.2281	158	0.22122	-0.4705	2.0177
Agent : Block	-3.6394	1.9493	-1.867	158	0.063748	-7.4893	0.21061
Agent : Game	1.1848	1.1962	0.99047	158	0.32346	-1.1778	3.5473
Block : Game	-0.90997	0.9963	-0.91335	158	0.36245	-2.8778	1.0578
Agent : Experience	-0.20234	0.41707	-0.48515	158	0.62824	-1.0261	0.62141
Block : Experience	0.15829	0.36415	0.43468	158	0.66439	-0.56094	0.87751
Game : Experience	-0.13373	0.23366	-0.57233	158	0.56791	-0.59524	0.32777

Table 6: Model fit to response variable of “I am playing well” (G1)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.9694	1.0546	1.8674	164	0.063637	-0.11304	4.0518
Block	1.9168	0.39977	4.7948	164	**3.6319e-06**	1.1274	2.7062
Game	1.2204	0.30518	3.9989	164	**9.6048e-05**	0.6178	1.823
Experience	0.32729	0.12129	2.6985	164	**0.0076942**	0.087808	0.56678
Agent : Block	-0.80197	0.62076	-1.2919	164	0.19821	-2.0277	0.42375
Agent : Game	-0.37579	0.20773	-1.809	164	0.072285	-0.78597	0.034391
Block : Game	-0.39684	0.18093	-2.1934	164	**0.029688**	-0.75409	-0.039593
Agent : Experience	-0.097033	0.073054	-1.3282	164	0.18595	-0.24128	0.047215
Block : Experience	-0.12775	0.065443	-1.952	164	0.052636	-0.25696	0.0014721
Game : Experience	-0.033548	0.041611	-0.80624	164	0.42127	-0.11571	0.048614

Table 7: Model fit to response variable of “The agent is playing poorly” (G2)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	-0.33608	1.0745	-0.31277	164	0.75485	-2.4577	1.7856
Block	0.83106	0.50514	1.6452	164	0.10184	-0.16635	1.8285
Game	1.1238	0.3918	2.8684	164	**0.0046687**	0.35021	1.8975
Experience	0.62968	0.15572	4.0436	164	**8.0826e-05**	0.3222	0.93717
Agent : Block	0.45465	0.48308	0.94115	164	0.34801	-0.49921	1.4085
Agent : Game	-0.11362	0.29781	-0.38151	164	0.70332	-0.70165	0.47441
Block : Game	-0.29889	0.24918	-1.1995	164	0.23207	-0.7909	0.19313
Agent : Experience	0.16086	0.10481	1.5348	164	0.12677	-0.046092	0.36782
Block : Experience	-0.16477	0.091074	-1.8092	164	0.072251	-0.3446	0.015057
Game : Experience	-0.10097	0.058624	-1.7223	164	0.086904	-0.21672	0.014788

Table 8: Model fit to response variable of “The team is playing well” (G3)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.3927	0.98213	1.418	164	0.15807	-0.54654	3.3319
Block	2.4468	0.46171	5.2995	164	**3.6985e-07**	1.5352	3.3585
Game	1.065	0.35812	2.9739	164	**0.0033848**	0.35787	1.7721
Experience	-0.032564	0.14234	-0.22878	164	0.81933	-0.31361	0.24848
Agent : Block	-0.58469	0.44155	-1.3242	164	0.18729	-1.4565	0.28716
Agent : Game	-0.22945	0.2722	-0.84293	164	0.4005	-0.76692	0.30803
Block : Game	-0.56663	0.22776	-2.4879	164	**0.01385**	-1.0163	-0.11692
Agent : Experience	-0.19952	0.095802	-2.0826	164	**0.03884**	-0.38868	-0.010353
Block : Experience	-0.076342	0.083244	-0.91709	164	0.36044	-0.24071	0.088027
Game : Experience	0.051342	0.053584	0.95816	164	0.33939	-0.054461	0.15715

Table 9: Model fit to response variable of “The game went well” (G4)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	0.76539	1.1659	0.65651	164	0.51242	-1.5366	3.0674
Block	2.0535	0.54808	3.7468	164	**0.00024779**	0.97132	3.1357
Game	1.8013	0.42511	4.2372	164	**3.7659e-05**	0.96187	2.6407
Experience	-0.16132	0.16896	-0.95475	164	0.34111	-0.49494	0.17231
Agent : Block	-0.34362	0.52415	-0.65558	164	0.51301	-1.3786	0.69133
Agent : Game	-0.076741	0.32312	-0.2375	164	0.81257	-0.71476	0.56128
Block : Game	-0.90768	0.27036	-3.3573	164	**0.00097855**	-1.4415	-0.37384
Agent : Experience	-0.17102	0.11372	-1.5038	164	0.13455	-0.39557	0.053529
Block : Experience	0.086306	0.098817	0.8734	164	0.38372	-0.10881	0.28142
Game : Experience	-0.00048774	0.063608	-0.0076679	164	0.99389	-0.12608	0.12511

Table 10: Model fit to response variable of “The agent and I have good teamwork” (G5)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	2.3867	0.92567	2.5783	164	**0.010807**	0.55891	4.2145
Block	2.5072	0.43517	5.7614	164	**4.0236e-08**	1.6479	3.3664
Game	1.2232	0.33753	3.6238	164	**0.00038684**	0.55669	1.8896
Experience	-0.026039	0.13415	-0.1941	164	0.84634	-0.29093	0.23885
Agent : Block	-0.84574	0.41617	-2.0322	164	**0.043746**	-1.6675	-0.024003
Agent : Game	-0.36521	0.25656	-1.4235	164	0.15649	-0.87179	0.14137
Block : Game	-0.59262	0.21467	-2.7607	164	**0.0064254**	-1.0165	-0.16876
Agent : Experience	-0.27275	0.090295	-3.0207	164	**0.0029261**	-0.45105	-0.094464
Block : Experience	-0.080736	0.078459	-1.029	164	0.30499	-0.23566	0.074185
Game : Experience	0.024633	0.050504	0.48775	164	0.62638	-0.075089	0.12435

Table 11: Model fit to response variable of “The agent is contributing to the success of the team” (G6)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.782	1.191	1.4963	164	0.13651	-0.56962	4.1336
Block	2.441	0.48735	5.0086	164	**1.4056e-06**	1.4787	3.4032
Game	1.4781	0.37685	3.9222	164	**0.00012878**	0.73397	2.2222
Experience	0.1814	0.14897	1.2177	164	0.22509	-0.11275	0.47556
Agent : Block	-0.74292	0.65379	-1.1363	164	0.25747	-2.0338	0.548
Agent : Game	-0.23663	0.2688	-0.88034	164	0.37997	-0.76739	0.29412
Block : Game	-0.62886	0.23001	-2.7341	164	**0.0069428**	-1.083	-0.1747
Agent : Experience	-0.17078	0.094562	-1.806	164	0.072747	-0.3575	0.015934
Block : Experience	-0.070518	0.083572	-0.8438	164	0.40001	-0.23553	0.094498
Game : Experience	-0.065545	0.053426	-1.2268	164	0.22164	-0.17104	0.039946

Table 12: Model fit to response variable of “I understand the agent’s intentions” (G7)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.4938	0.86912	1.7188	164	0.087537	-0.22226	3.2099
Block	2.6995	0.40858	6.6069	164	**5.2348e-10**	1.8927	3.5062
Game	1.6848	0.31691	5.3164	164	**3.4175e-07**	1.0591	2.3106
Experience	-0.011884	0.12596	-0.09435	164	0.92495	-0.26059	0.23682
Agent : Block	-0.55231	0.39074	-1.4135	164	0.1594	-1.3238	0.21922
Agent : Game	-0.42332	0.24088	-1.7574	164	0.08072	-0.89895	0.05231
Block : Game	-0.78483	0.20155	-3.8939	164	**0.00014328**	-1.1828	-0.38686
Agent : Experience	-0.19273	0.084778	-2.2734	164	**0.024301**	-0.36013	-0.025335
Block : Experience	-0.10565	0.073666	-1.4341	164	0.15343	-0.2511	0.039808
Game : Experience	0.019661	0.047418	0.41464	164	0.67895	-0.073968	0.11329

Table 13: Model fit to response variable of “The agent does not understand my intentions” (G8)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.1503	1.2751	0.90212	164	0.36831	-1.3675	3.6682
Block	1.3412	0.51911	2.5838	164	**0.010645**	0.31625	2.3662
Game	1.3544	0.40121	3.3757	164	**0.00091923**	0.56216	2.1466
Experience	0.3328	0.15861	2.0982	164	**0.037422**	0.019612	0.64598
Agent : Block	-0.84719	0.70374	-1.2039	164	0.23038	-2.2367	0.54236
Agent : Game	-0.23748	0.28536	-0.83219	164	0.40651	-0.80093	0.32598
Block : Game	-0.43934	0.24444	-1.7974	164	0.074115	-0.92199	0.043303
Agent : Experience	0.3178	0.10039	3.1657	164	**0.0018446**	0.11958	0.51602
Block : Experience	-0.048055	0.088791	-0.54122	164	0.58909	-0.22338	0.12727
Game : Experience	-0.10706	0.056744	-1.8867	164	0.060972	-0.2191	0.0049858

Table 14: Model fit to response variable of “I feel comfortable playing with this agent” (G9)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	3.143	0.95194	3.3017	164	**0.0011796**	1.2633	5.0226
Block	2.5133	0.44752	5.616	164	**8.1919e-08**	1.6296	3.3969
Game	1.0899	0.34711	3.1398	164	**0.0020055**	0.40448	1.7752
Experience	-0.023996	0.13796	-0.17393	164	0.86213	-0.29641	0.24841
Agent : Block	-1.0492	0.42798	-2.4516	164	**0.015273**	-1.8943	-0.20415
Agent : Game	-0.34819	0.26384	-1.3197	164	0.18877	-0.86914	0.17277
Block : Game	-0.49785	0.22076	-2.2552	164	**0.025444**	-0.93375	-0.061956
Agent : Experience	-0.33071	0.092857	-3.5614	164	**0.00048298**	-0.51406	-0.14736
Block : Experience	-0.081598	0.080686	-1.0113	164	0.31336	-0.24092	0.077719
Game : Experience	0.022646	0.051937	0.43602	164	0.66339	-0.079906	0.1252

Table 15: Model fit to response variable of “I do not trust the agent” (G10)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	-0.80019	1.0903	-0.73389	164	0.46406	-2.9531	1.3527
Block	1.0878	0.51258	2.1221	164	**0.03533**	0.075645	2.0999
Game	1.1899	0.39758	2.9929	164	**0.0031911**	0.40487	1.9749
Experience	0.6055	0.15802	3.8318	164	**0.00018089**	0.29349	0.91752
Agent : Block	0.83804	0.4902	1.7096	164	0.089233	-0.12987	1.806
Agent : Game	-0.20681	0.3022	-0.68436	164	0.49472	-0.80351	0.38989
Block : Game	-0.37637	0.25285	-1.4885	164	0.13854	-0.87564	0.1229
Agent : Experience	0.203	0.10636	1.9086	164	0.058055	-0.0070082	0.413
Block : Experience	-0.17691	0.092417	-1.9143	164	0.057328	-0.35939	0.0055706
Game : Experience	-0.076328	0.059488	-1.2831	164	0.20127	-0.19379	0.041133

Table 16: Model fit to response variable of “The agent is not a reliable teammate” (G11)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	0.34397	1.1345	0.3032	164	0.76212	-1.8961	2.584
Block	1.0037	0.53332	1.8821	164	0.061598	-0.049315	2.0568
Game	1.0982	0.41366	2.6549	164	**0.0087148**	0.28145	1.915
Experience	0.51945	0.16441	3.1594	164	**0.0018826**	0.19481	0.84409
Agent : Block	0.12847	0.51003	0.25188	164	0.80145	-0.87861	1.1355
Agent : Game	-0.1499	0.31442	-0.47675	164	0.63417	-0.77074	0.47094
Block : Game	-0.30352	0.26308	-1.1537	164	0.2503	-0.82299	0.21595
Agent : Experience	0.12813	0.11066	1.1579	164	0.24859	-0.090369	0.34664
Block : Experience	-0.088578	0.096156	-0.9212	164	0.3583	-0.27844	0.10128
Game : Experience	-0.097645	0.061895	-1.5776	164	0.11659	-0.21986	0.024569

Table 17: Model fit to response variable of “I am not confident in my gameplay” (G12)

Name	Estimate	SE	t	df	p	Lower	Upper
Agent	1.4796	1.2583	1.1758	164	0.24137	-1.005	3.9641
Block	1.5481	0.4575	3.3839	164	**0.00089398**	0.64478	2.4515
Game	0.61849	0.34399	1.798	164	0.074017	-0.060728	1.2977
Experience	0.26304	0.13801	1.906	164	0.058405	-0.0094638	0.53554
Agent : Block	-1.1132	0.76425	-1.4565	164	0.14716	-2.6222	0.39588
Agent : Game	0.037263	0.22698	0.16417	164	0.8698	-0.41092	0.48544
Block : Game	-0.29982	0.20014	-1.498	164	0.13605	-0.69501	0.095368
Agent : Experience	0.031346	0.079802	0.39279	164	0.69498	-0.12623	0.18892
Block : Experience	-0.044646	0.07217	-0.61861	164	0.53703	-0.18715	0.097857
Game : Experience	-0.048831	0.045717	-1.0681	164	0.28704	-0.1391	0.041439

6.8 Novice vs Expert Post-Game t-Tests

Post-hoc pairwise comparisons of novice vs expert in cases where agent and self-reported Hanabi experience have significant interaction effects, as described in Section 4.2.

Table 18: Two-sample t-tests of post-game sentiment, comparing novice and expert reactions.

Question	Agent	t	p	corrected p	d
G5	SB	0.35599	0.72273	1.00000	0.080708
G5	OP	5.1395	1.7334e-06	**1.38672e-05**	1.0185
G9	SB	0.25536	0.79906	1.00000	0.057915
G9	OP	5.8552	8.7246e-08	**7.85214e-07**	1.1214
G8	SB	0.61126	0.54266	1.00000	0.13838
G8	OP	-5.9229	6.5231e-08	**6.52310e-07**	-1.1306
G3	SB	-1.1856	0.2391	0.956400	-0.26679
G3	OP	3.5514	0.00062779	**3.76674e-03**	0.75189
G7	SB	1.652	0.10223	0.511150	0.36893
G7	OP	5.0678	2.3171e-06	**1.62197e-05**	1.0076

6.9 Post-Experiment t-Tests

One-sample t-tests of post-experiment sentiment. Some responses were flipped on the Likert scale for directional consistency, based on which agent was seen first, since the ends of the scale were labeled as the “first” and “second” agent for the participants. Preference directionality is such that 1 is towards OP and 7 is towards SB. t statistics greater than 0 indicate answering towards SB. The Holm–Bonferroni step-down method was used for multiple comparisons correction. d is the Cohen’s effect size. In general, thresholds for “small,” “medium,” and “large” effect sizes are considered to be $|d| = 0.2, 0.5$, and 0.8 respectively [10].

Table 19: One-sample t-tests of post-experiment sentiment.

Question	t	p	corrected p	d
Which agent did you prefer playing with?	2.90633	0.00707	**0.03969**	0.549
Which agent did you trust more?	3.40564	0.00201	**0.01610**	0.644
Which agent did you understand more?	2.88618	0.00743	**0.03969**	0.545
Which agent understood you better?	2.93369	0.00661	**0.03969**	0.554
Which agent was the better Hanabi player?	3.36011	0.00226	**0.01610**	0.635
Which agent was more reliable?	2.86217	0.00788	**0.03969**	0.541
Which agent had a better understanding of the game on average?	2.68186	0.01214	**0.03969**	0.507
Which agent caused you to have a greater mental workload?	-0.16385	0.87103	0.87103	-0.031

6.10 Post-Experiment Participant Preference and Free Response

Post-experiment ratings of agent preference and explanation of the preference. The “Preference” heading corresponds to a Likert-scale response to the question “Which agent did you prefer playing with?” where 1 was “the first agent” and 7 was “the second agent.” “Explanation” was a free-response field with the question “Why did you prefer the agent that you did?”

Table 20: Post-experiment ratings of agent preference and explanation

Participant	Order	Preference	Explanation
1	SB, OP	5	first agent felt like it was learning; really bad to begin with; had to "teach" them how to play hanabi; second agent felt like someone who knew how to play hanabi and wanted to trick you; broke my trust in 2nd game; in 3rd game was "trust me"; don’t like playing with 2nd agent.

2	OP, SB	6	It seemed to have a better understanding of not just what hints to give, but when to give them. I think a lot of the strategies cascaded from that - both my strategy and its. It just had a better understanding of the tempo of the game. If you think of it as - every time I get a hint, I have to perform an MLE, and when I give a hint, that's what they have to perform - if you just take the clue at face value; you can think about "why am I giving this hint" the second agent thought about "why am I getting/giving this hint NOW" while the first agent didn't.
3	SB, OP	1	It knew the rules of the game. It knew how to play.
4	OP, SB	4	I thought the first one was dumber but more consistent. The second one - I thought I was starting to understand it in the second game, but then in the third game, I completely didn't understand what it was doing at all.
5	SB, OP	1	Second agent made an obvious mistake quite frequently. There are some cases where it was clear that if the agent played a card, we would lose the game, but it played it anyway. Sometimes it would also give me hints that I already know.
6	OP, SB	7	better able to understand what it's clues meant and how to give it clues that would result in the correct actions
7	SB, OP	3	The first agent was more predictable, even if I didn't necessarily agree with their strategy. Both of them made dumb choices, like playing cards that were clearly not playable when they had full information on them (or at least enough information), or they discarded cards with full information and were playable.
8	OP, SB	7	The second agent seemed to be more capable of inductive reasoning than the first. Both has similar styles of inductive clues, but it seemed like the second took inductive clues better. The discard strategy of the first agent felt worse than the discard strategy of the second.
9	SB, OP	1	agent 1 was more consistent; even if i didn't understand what they were doing, i could more reliably assume they would play or discard cards if they knew they were playable; I feel I bombed the second one whenever i clued it; did not know how it would react
10	OP, SB	6	Maybe it's because the first one was so terrible that it made me have zero expectation of the second one. So even though the second agent wasn't that much better, and I was confused by its strategy, I was used to being confused and wasn't surprised anymore. It took less willpower to go through the games [with the second agent].
11	SB, OP	7	Gave me info; seemed to act on cues better; it felt like there was 2-way comms as opposed to 1-way; also it didn't throw away cards (e.g., knew perfect info on)
12	OP, SB	7	It provided more challenge and interest. Because I could reasonably play with it. It let me play at a more satisfying level.

13	SB, OP	1	Agent 1 seemed to have a better model of the game in the sense that it deliberately played playable cards and discarded unplayable cards more frequently; as opposed to the 2nd agent that played known unplayable cards and did not play cards when it had the chance to; first agent was more inline with game of Hanabi rules of playing all cards when possible; first agent played a way that was more familiar; First agent still used strategies that were more human friendly; i understood it better and it understood me better
14	OP, SB	3	I felt like the first agent was improving and started understanding my strategy more, whereas the second one wasn't learning from the errors or mistakes that both of us made.
15	SB, OP	6	The rules that the second (2nd) agent was following was easier to understand; specifically the discarding strategy was much more predictable; first agent may have predictable discarding strategy, but the 2nd agent is much easier to play with
16	OP, SB	7	I probably had some learning effects for the game so I understood things better, however, I also found that it was easier to get into a cadence of play with the second agent. I think I understood the intention of the second agent and it understood me.
17	SB, OP	1	The first agent played cards and hinted cards consistently. The second agent by contrast did not play multiply-hinted cards and gave hints that were not necessarily playable. With the first agent, I could reasonably expect to perform well and to trust his decision whereas with the second agent, I found myself trying to compensate for his lack of reliability.
18	OP, SB	2	i was better at predicting what the first agent would do; after first 2 games i understood the agent's strategy though i didn't agree with it; with 2nd agent i couldn't figure out how it's saves and discards worked and that made it impossible for me to tell it to save cards i wanted to protect
19	SB, OP	1	because i could understand what it would do and i can predict what they would do better; and i have opinion that i can understand the clue of the first agent and what the agent tries to force me to do; the first agent preferred to play instead of discarding; second agent prefers to discard instead of play which is sub-optimal in hanabi game (i.e., it had full info about a card and still chose to discard)
20	OP, SB	7	It does understand rules of Hanabi among humans.
21	SB, OP	7	It gave me more hints and it didn't make inexplicable discard decisions that were clearly suboptimal based on information that it had at the time. It was also the only one of the six games that we completed (25 pts).
22	OP, SB	6	second agent played color clues that i gave
23	SB, OP	5	I felt that the second agent understood some clues better than the first even though i think they are very very similar; similar strategy on saving discarding cluing; main difference for the second one was that it would clue sooner than the first one; it wouldn't delay cluing even though it had cards; 3 games is a bit short to determine/assess strategy;
24	OP, SB	6	The main reason was that Agent 2 was willing to change its discard behavior to match mine, as I strongly prefer discarding the oldest card instead of the newest. The other reason is the second agent was a little better at giving clues to me that I understood the meaning of.

25	SB, OP	7	It seemed more cooperative in that it was giving a lot of hints and it seemed like we had a similar strategy. Early on, we'd tell each other when we had ones, and then giving full information, giving the appropriate hints for the state of the game. Seemed like we had good teamwork. They were giving hints, and also taking hints.
26	OP, SB	7	The second agent understood my strategy better; it was easier for me to follow it's pattern/strategy; and because we got closer to winning, ergo, it was doing something right
27	SB, OP	2	the first agent provides more certainty even though the game progresses slower, it acts upon certainty and minimizes guessing;
28	OP, SB	6	i felt like the second agent was playing with easier to understand set of rules; they appeared to be more mindful of hints or number of hints remaining, so there is a better back-and-forth depending on who what playable cards or not;
29	SB, OP	3	To my understanding, the strategy seemed very consistent and simple. Agent 2's strategy seemed more complex and less predictable. It seemed more random which is less preferable.