

Supplemental Material for [paper](#) titled "*Mitigating Response Delays in Free-Form Conversations with LLM-powered Intelligent Virtual Agents*" in [ACM CUI 2025](#).

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2 Packages Used

The following R packages were used to perform statistical analyses presented in the supplemental materials:

- dplyr <https://cran.r-project.org/package=dplyr>
- emmeans <https://cran.r-project.org/package=emmeans>
- ARTool <https://cran.r-project.org/package=ARTool>
- rstatix <https://cran.r-project.org/package=rstatix>
- effectsize <https://cran.r-project.org/package=effectsize>
- readr <https://cran.r-project.org/package=readr>

3 Statistical Results

3.1 ANOVA

Repeated-Measures ANOVA on ART-Transformed Data. η^2 is the effect size of a specific independent variable on the dependent variable (metric measured by the question), while controlling for effects of other independent variables.

Question	Factor	Df	Df.res	F Score	Pr(>F)	η^2
(Q1) Response Time	Delay	2	424	154.549	3.87E-51	0.422
(Q1) Response Time	Filler	2	424	18.613	1.79E-08	0.081
(Q1) Response Time	Delay:Filler	4	424	4.657	0.001	0.042
(Q2) Engagement	Delay	2	424	25.335	4.04E-11	0.107
(Q2) Engagement	Filler	2	424	4.676	0.01	0.022
(Q2) Engagement	Delay:Filler	4	424	1.082	0.365	0.01
(Q3) Good Impression	Delay	2	424	30.923	2.91E-13	0.127
(Q3) Good Impression	Filler	2	424	5.026	0.007	0.023
(Q3) Good Impression	Delay:Filler	4	424	0.365	0.834	0.003
(Q4) Discomfort	Delay	2	424	4.648	0.010	0.021
(Q4) Discomfort	Filler	2	424	1.278	0.28	0.006
(Q4) Discomfort	Delay:Filler	4	424	1.548	0.187	0.014
(Q5) Competence	Delay	2	424	14.737	6.49E-07	0.065
(Q5) Competence	Filler	2	424	3.735	0.025	0.017
(Q5) Competence	Delay:Filler	4	424	1.177	0.320	0.011
(Q6) Willingness to Interact Again	Delay	2	424	16.933	8.41E-08	0.074
(Q6) Willingness to Interact Again	Filler	2	424	2.26	0.106	0.011
(Q6) Willingness to Interact Again	Delay:Filler	4	424	0.424	0.791	0.004

3.2 Contrast Results

Post-hoc pairwise comparisons were conducted using the estimated marginal means derived from ART-transformed data. These contrasts evaluate specific differences between individual levels of independent variables. Reported values per question per contrast include degrees of freedom (df), t-ratio, and associated p-value for each comparison, returned by ART-C package.

Question	Contrast	Df	t.ratio	p.value
(Q1) Response Time	High,Artificial - High,Natural	424	-2.281	0.161
(Q1) Response Time	High,Artificial - High,none	424	2.518	0.097
(Q1) Response Time	High,Artificial - Low,Artificial	424	-9.969	1.15E-19
(Q1) Response Time	High,Artificial - Low,Natural	424	-10.7	2.70E-22
(Q1) Response Time	High,Artificial - Low,none	424	-9.871	2.47E-19
(Q1) Response Time	High,Artificial - Medium,Artificial	424	-3.414	0.008
(Q1) Response Time	High,Artificial - Medium,Natural	424	-6.35	1.11E-08
(Q1) Response Time	High,Artificial - Medium,none	424	-2.68	0.069
(Q1) Response Time	High,Natural - High,none	424	4.799	3.76E-05
(Q1) Response Time	High,Natural - Low,Artificial	424	-7.687	2.85E-12
(Q1) Response Time	High,Natural - Low,Natural	424	-8.419	1.72E-14
(Q1) Response Time	High,Natural - Low,none	424	-7.59	5.34E-12
(Q1) Response Time	High,Natural - Medium,Artificial	424	-1.133	1
(Q1) Response Time	High,Natural - Medium,Natural	424	-4.069	0.001
(Q1) Response Time	High,Natural - Medium,none	424	-0.399	1
(Q1) Response Time	High,none - Low,Artificial	424	-12.487	3.83E-29
(Q1) Response Time	High,none - Low,Natural	424	-13.218	4.38E-32
(Q1) Response Time	High,none - Low,none	424	-12.389	9.09E-29
(Q1) Response Time	High,none - Medium,Artificial	424	-5.932	1.18E-07
(Q1) Response Time	High,none - Medium,Natural	424	-8.868	6.27E-16
(Q1) Response Time	High,none - Medium,none	424	-5.198	5.65E-06
(Q1) Response Time	Low,Artificial - Low,Natural	424	-0.731	1
(Q1) Response Time	Low,Artificial - Low,none	424	0.097	1
(Q1) Response Time	Low,Artificial - Medium,Artificial	424	6.554	3.57E-09
(Q1) Response Time	Low,Artificial - Medium,Natural	424	3.618	0.004
(Q1) Response Time	Low,Artificial - Medium,none	424	7.289	3.86E-11
(Q1) Response Time	Low,Natural - Low,none	424	0.828	1
(Q1) Response Time	Low,Natural - Medium,Artificial	424	7.286	3.86E-11
(Q1) Response Time	Low,Natural - Medium,Natural	424	4.349	0.000274
(Q1) Response Time	Low,Natural - Medium,none	424	8.02	2.92E-13
(Q1) Response Time	Low,none - Medium,Artificial	424	6.457	6.15E-09
(Q1) Response Time	Low,none - Medium,Natural	424	3.521	0.006
(Q1) Response Time	Low,none - Medium,none	424	7.191	6.73E-11

Question	Contrast	Df	t.ratio	p.value
(Q1) Response Time	Medium,Artificial - Medium,Natural	424	-2.936	0.035
(Q1) Response Time	Medium,Artificial - Medium,none	424	0.734	1
(Q1) Response Time	Medium,Natural - Medium,none	424	3.67	0.004
(Q2) Engagement	High,Artificial - High,Natural	424	-1.468	1
(Q2) Engagement	High,Artificial - High,none	424	1.393	1
(Q2) Engagement	High,Artificial - Low,Artificial	424	-3.968	0.003
(Q2) Engagement	High,Artificial - Low,Natural	424	-4.717	0.000108
(Q2) Engagement	High,Artificial - Low,none	424	-4.41	0.00042
(Q2) Engagement	High,Artificial - Medium,Artificial	424	-1.7	1
(Q2) Engagement	High,Artificial - Medium,Natural	424	-2.644	0.187
(Q2) Engagement	High,Artificial - Medium,none	424	-2.143	0.556
(Q2) Engagement	High,Natural - High,none	424	2.861	0.106
(Q2) Engagement	High,Natural - Low,Artificial	424	-2.5	0.256
(Q2) Engagement	High,Natural - Low,Natural	424	-3.249	0.035
(Q2) Engagement	High,Natural - Low,none	424	-2.942	0.086
(Q2) Engagement	High,Natural - Medium,Artificial	424	-0.232	1
(Q2) Engagement	High,Natural - Medium,Natural	424	-1.176	1
(Q2) Engagement	High,Natural - Medium,none	424	-0.675	1
(Q2) Engagement	High,none - Low,Artificial	424	-5.361	4.64E-06
(Q2) Engagement	High,none - Low,Natural	424	-6.11	8.15E-08
(Q2) Engagement	High,none - Low,none	424	-5.803	4.47E-07
(Q2) Engagement	High,none - Medium,Artificial	424	-3.093	0.057
(Q2) Engagement	High,none - Medium,Natural	424	-4.037	0.002
(Q2) Engagement	High,none - Medium,none	424	-3.536	0.013
(Q2) Engagement	Low,Artificial - Low,Natural	424	-0.749	1
(Q2) Engagement	Low,Artificial - Low,none	424	-0.442	1
(Q2) Engagement	Low,Artificial - Medium,Artificial	424	2.268	0.453
(Q2) Engagement	Low,Artificial - Medium,Natural	424	1.324	1
(Q2) Engagement	Low,Artificial - Medium,none	424	1.825	1
(Q2) Engagement	Low,Natural - Low,none	424	0.307	1
(Q2) Engagement	Low,Natural - Medium,Artificial	424	3.017	0.07
(Q2) Engagement	Low,Natural - Medium,Natural	424	2.073	0.621
(Q2) Engagement	Low,Natural - Medium,none	424	2.574	0.218
(Q2) Engagement	Low,none - Medium,Artificial	424	2.71	0.161
(Q2) Engagement	Low,none - Medium,Natural	424	1.766	1
(Q2) Engagement	Low,none - Medium,none	424	2.267	0.453
(Q2) Engagement	Medium,Artificial - Medium,Natural	424	-0.944	1
(Q2) Engagement	Medium,Artificial - Medium,none	424	-0.443	1

Question	Contrast	Df	t.ratio	p.value
(Q2) Engagement	Medium,Natural - Medium,none	424	0.501	1
(Q3) Good Impression	High,Artificial - High,Natural	424	-0.788	1
(Q3) Good Impression	High,Artificial - High,none	424	-0.084	1
(Q3) Good Impression	High,Artificial - Low,Artificial	424	-3.893	0.003
(Q3) Good Impression	High,Artificial - Low,Natural	424	-4.778	8.78E-05
(Q3) Good Impression	High,Artificial - Low,none	424	-4.257	0.001
(Q3) Good Impression	High,Artificial - Medium,Artificial	424	-0.809	1
(Q3) Good Impression	High,Artificial - Medium,Natural	424	-2.993	0.064
(Q3) Good Impression	High,Artificial - Medium,none	424	-1.221	1
(Q3) Good Impression	High,Natural - High,none	424	0.705	1
(Q3) Good Impression	High,Natural - Low,Artificial	424	-3.104	0.051
(Q3) Good Impression	High,Natural - Low,Natural	424	-3.99	0.002
(Q3) Good Impression	High,Natural - Low,none	424	-3.468	0.016
(Q3) Good Impression	High,Natural - Medium,Artificial	424	-0.021	1
(Q3) Good Impression	High,Natural - Medium,Natural	424	-2.204	0.533
(Q3) Good Impression	High,Natural - Medium,none	424	-0.433	1
(Q3) Good Impression	High,none - Low,Artificial	424	-3.809	0.005
(Q3) Good Impression	High,none - Low,Natural	424	-4.695	0.000126
(Q3) Good Impression	High,none - Low,none	424	-4.173	0.001
(Q3) Good Impression	High,none - Medium,Artificial	424	-0.725	1
(Q3) Good Impression	High,none - Medium,Natural	424	-2.909	0.08
(Q3) Good Impression	High,none - Medium,none	424	-1.137	1
(Q3) Good Impression	Low,Artificial - Low,Natural	424	-0.886	1
(Q3) Good Impression	Low,Artificial - Low,none	424	-0.364	1
(Q3) Good Impression	Low,Artificial - Medium,Artificial	424	3.083	0.052
(Q3) Good Impression	Low,Artificial - Medium,Natural	424	0.9	1
(Q3) Good Impression	Low,Artificial - Medium,none	424	2.672	0.157
(Q3) Good Impression	Low,Natural - Low,none	424	0.522	1
(Q3) Good Impression	Low,Natural - Medium,Artificial	424	3.969	0.003
(Q3) Good Impression	Low,Natural - Medium,Natural	424	1.786	1
(Q3) Good Impression	Low,Natural - Medium,none	424	3.558	0.012
(Q3) Good Impression	Low,none - Medium,Artificial	424	3.447	0.016
(Q3) Good Impression	Low,none - Medium,Natural	424	1.264	1
(Q3) Good Impression	Low,none - Medium,none	424	3.036	0.059
(Q3) Good Impression	Medium,Artificial - Medium,Natural	424	-2.183	0.533
(Q3) Good Impression	Medium,Artificial - Medium,none	424	-0.412	1
(Q3) Good Impression	Medium,Natural - Medium,none	424	1.772	1
(Q4) Discomfort	High,Artificial - High,Natural	424	1.197	1

Question	Contrast	Df	t.ratio	p.value
(Q4) Discomfort	High,Artificial - High,none	424	-0.511	1
(Q4) Discomfort	High,Artificial - Low,Artificial	424	2.869	0.121
(Q4) Discomfort	High,Artificial - Low,Natural	424	4.057	0.002
(Q4) Discomfort	High,Artificial - Low,none	424	3.317	0.031
(Q4) Discomfort	High,Artificial - Medium,Artificial	424	0.166	1
(Q4) Discomfort	High,Artificial - Medium,Natural	424	1.095	1
(Q4) Discomfort	High,Artificial - Medium,none	424	2.219	0.644
(Q4) Discomfort	High,Natural - High,none	424	-1.708	1
(Q4) Discomfort	High,Natural - Low,Artificial	424	1.671	1
(Q4) Discomfort	High,Natural - Low,Natural	424	2.86	0.121
(Q4) Discomfort	High,Natural - Low,none	424	2.119	0.762
(Q4) Discomfort	High,Natural - Medium,Artificial	424	-1.031	1
(Q4) Discomfort	High,Natural - Medium,Natural	424	-0.102	1
(Q4) Discomfort	High,Natural - Medium,none	424	1.021	1
(Q4) Discomfort	High,none - Low,Artificial	424	3.379	0.025
(Q4) Discomfort	High,none - Low,Natural	424	4.568	0.000233
(Q4) Discomfort	High,none - Low,none	424	3.827	0.005
(Q4) Discomfort	High,none - Medium,Artificial	424	0.677	1
(Q4) Discomfort	High,none - Medium,Natural	424	1.606	1
(Q4) Discomfort	High,none - Medium,none	424	2.73	0.172
(Q4) Discomfort	Low,Artificial - Low,Natural	424	1.189	1
(Q4) Discomfort	Low,Artificial - Low,none	424	0.448	1
(Q4) Discomfort	Low,Artificial - Medium,Artificial	424	-2.702	0.179
(Q4) Discomfort	Low,Artificial - Medium,Natural	424	-1.773	1
(Q4) Discomfort	Low,Artificial - Medium,none	424	-0.65	1
(Q4) Discomfort	Low,Natural - Low,none	424	-0.741	1
(Q4) Discomfort	Low,Natural - Medium,Artificial	424	-3.891	0.004
(Q4) Discomfort	Low,Natural - Medium,Natural	424	-2.962	0.094
(Q4) Discomfort	Low,Natural - Medium,none	424	-1.839	1
(Q4) Discomfort	Low,none - Medium,Artificial	424	-3.151	0.052
(Q4) Discomfort	Low,none - Medium,Natural	424	-2.222	0.644
(Q4) Discomfort	Low,none - Medium,none	424	-1.098	1
(Q4) Discomfort	Medium,Artificial - Medium,Natural	424	0.929	1
(Q4) Discomfort	Medium,Artificial - Medium,none	424	2.053	0.855
(Q4) Discomfort	Medium,Natural - Medium,none	424	1.124	1
(Q5) Competence	High,Artificial - High,Natural	424	-0.503	1
(Q5) Competence	High,Artificial - High,none	424	0.18	1
(Q5) Competence	High,Artificial - Low,Artificial	424	-3.576	0.012

Question	Contrast	Df	t.ratio	p.value
(Q5) Competence	High,Artificial - Low,Natural	424	-3.496	0.016
(Q5) Competence	High,Artificial - Low,none	424	-3.693	0.009
(Q5) Competence	High,Artificial - Medium,Artificial	424	-0.589	1
(Q5) Competence	High,Artificial - Medium,Natural	424	-3.26	0.035
(Q5) Competence	High,Artificial - Medium,none	424	-1.116	1
(Q5) Competence	High,Natural - High,none	424	0.683	1
(Q5) Competence	High,Natural - Low,Artificial	424	-3.073	0.059
(Q5) Competence	High,Natural - Low,Natural	424	-2.993	0.073
(Q5) Competence	High,Natural - Low,none	424	-3.19	0.043
(Q5) Competence	High,Natural - Medium,Artificial	424	-0.085	1
(Q5) Competence	High,Natural - Medium,Natural	424	-2.757	0.134
(Q5) Competence	High,Natural - Medium,none	424	-0.613	1
(Q5) Competence	High,none - Low,Artificial	424	-3.756	0.007
(Q5) Competence	High,none - Low,Natural	424	-3.676	0.009
(Q5) Competence	High,none - Low,none	424	-3.873	0.004
(Q5) Competence	High,none - Medium,Artificial	424	-0.769	1
(Q5) Competence	High,none - Medium,Natural	424	-3.44	0.019
(Q5) Competence	High,none - Medium,none	424	-1.296	1
(Q5) Competence	Low,Artificial - Low,Natural	424	0.08	1
(Q5) Competence	Low,Artificial - Low,none	424	-0.117	1
(Q5) Competence	Low,Artificial - Medium,Artificial	424	2.988	0.073
(Q5) Competence	Low,Artificial - Medium,Natural	424	0.316	1
(Q5) Competence	Low,Artificial - Medium,none	424	2.46	0.271
(Q5) Competence	Low,Natural - Low,none	424	-0.197	1
(Q5) Competence	Low,Natural - Medium,Artificial	424	2.907	0.088
(Q5) Competence	Low,Natural - Medium,Natural	424	0.236	1
(Q5) Competence	Low,Natural - Medium,none	424	2.38	0.32
(Q5) Competence	Low,none - Medium,Artificial	424	3.104	0.055
(Q5) Competence	Low,none - Medium,Natural	424	0.433	1
(Q5) Competence	Low,none - Medium,none	424	2.577	0.206
(Q5) Competence	Medium,Artificial - Medium,Natural	424	-2.672	0.165
(Q5) Competence	Medium,Artificial - Medium,none	424	-0.528	1
(Q5) Competence	Medium,Natural - Medium,none	424	2.144	0.554
(Q6) Willingness to Interact Again	High,Artificial - High,Natural	424	-0.857	1
(Q6) Willingness to Interact Again	High,Artificial - High,none	424	0.729	1
(Q6) Willingness to Interact Again	High,Artificial - Low,Artificial	424	-3.806	0.005
(Q6) Willingness to Interact Again	High,Artificial - Low,Natural	424	-4.036	0.002
(Q6) Willingness to Interact Again	High,Artificial - Low,none	424	-3.497	0.016

Question	Contrast	Df	t.ratio	p.value
(Q6) Willingness to Interact Again	High,Artificial - Medium,Artificial	424	-0.841	1
(Q6) Willingness to Interact Again	High,Artificial - Medium,Natural	424	-2.248	0.502
(Q6) Willingness to Interact Again	High,Artificial - Medium,none	424	-1.204	1
(Q6) Willingness to Interact Again	High,Natural - High,none	424	1.586	1
(Q6) Willingness to Interact Again	High,Natural - Low,Artificial	424	-2.949	0.087
(Q6) Willingness to Interact Again	High,Natural - Low,Natural	424	-3.179	0.046
(Q6) Willingness to Interact Again	High,Natural - Low,none	424	-2.64	0.198
(Q6) Willingness to Interact Again	High,Natural - Medium,Artificial	424	0.016	1
(Q6) Willingness to Interact Again	High,Natural - Medium,Natural	424	-1.391	1
(Q6) Willingness to Interact Again	High,Natural - Medium,none	424	-0.347	1
(Q6) Willingness to Interact Again	High,none - Low,Artificial	424	-4.535	0.000263
(Q6) Willingness to Interact Again	High,none - Low,Natural	424	-4.765	9.37E-05
(Q6) Willingness to Interact Again	High,none - Low,none	424	-4.226	0.001
(Q6) Willingness to Interact Again	High,none - Medium,Artificial	424	-1.57	1
(Q6) Willingness to Interact Again	High,none - Medium,Natural	424	-2.977	0.086
(Q6) Willingness to Interact Again	High,none - Medium,none	424	-1.933	1
(Q6) Willingness to Interact Again	Low,Artificial - Low,Natural	424	-0.229	1
(Q6) Willingness to Interact Again	Low,Artificial - Low,none	424	0.309	1
(Q6) Willingness to Interact Again	Low,Artificial - Medium,Artificial	424	2.965	0.086
(Q6) Willingness to Interact Again	Low,Artificial - Medium,Natural	424	1.558	1
(Q6) Willingness to Interact Again	Low,Artificial - Medium,none	424	2.602	0.211
(Q6) Willingness to Interact Again	Low,Natural - Low,none	424	0.539	1
(Q6) Willingness to Interact Again	Low,Natural - Medium,Artificial	424	3.195	0.045
(Q6) Willingness to Interact Again	Low,Natural - Medium,Natural	424	1.788	1
(Q6) Willingness to Interact Again	Low,Natural - Medium,none	424	2.831	0.121
(Q6) Willingness to Interact Again	Low,none - Medium,Artificial	424	2.656	0.197
(Q6) Willingness to Interact Again	Low,none - Medium,Natural	424	1.249	1
(Q6) Willingness to Interact Again	Low,none - Medium,none	424	2.292	0.47
(Q6) Willingness to Interact Again	Medium,Artificial - Medium,Natural	424	-1.407	1
(Q6) Willingness to Interact Again	Medium,Artificial - Medium,none	424	-0.363	1
(Q6) Willingness to Interact Again	Medium,Natural - Medium,none	424	1.043	1