Contents

1 Introduction

In the manuscript, we presented the critical effects pertinent to our research question. This supplementary file not only contains the full ANOVA results, including all main effects and interactions, but also reports an analogous set of linear mixed-effect models. Besides accounting for within-subject/trial-level variability, the current models utilize the full age-range within our sample (18-89 years old) to provide additional sensitivity in estimating the relationship between age and utilization of cognitive control. Furthermore, considering our hypotheses regarding the relative decrements in proactive versus reactive control, a key goal of these analyses is to estimate the specific age value in which the magnitude of effects reflecting proactive control would be reduced to zero. This value is computed across different indicators of proactive control (i.e., LWPC effect, congruency cost, color naming cost).

In terms of selecting an optimal approach for model building, a maximal random effect structure was chosen (Meteyard and Davies, 2020). Such models not only tend to have higher predictive accuracy, due to the more accurate modeling of subject-level dependencies as well as the shrinkage of outlying subject-level estimates, but also have more logical interpretations in the context of our project (i.e., subjects may deviate significantly in their implementation of proactive and reactive control). Pairwise model comparisons across three LWPC models (i.e., one with just mode as a random slope, one with mode and trial type as independent effects, and one with mode and trial type as an interaction effect) showed that the most complex model led to a significantly better fit of the data, and this result was used as evidence to generalize the approach, such that all mixed-effect models utilized a maximal random effects structure. To reduce complexity of these mixed-effect models, unlike the repeated-measures ANOVAs reported in the main text, these analyses do not include the condition order factor.

We also conducted an additional set of analyses aimed to both further our claims of age-related differences in proactive and reactive control as well as address potential factors that were not explored in our key ANOVA and LME results. A more detailed explanation for each will be presented in their respective sections.

2 Full ANOVA Results

2.1 Color Naming LWPC Effect

Table 1: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η_p^2
Condition Order	1	321	821.47	6329361.12	0.04	0.838	0.00
Age	2	321	86277.99	6329361.12	2.19	0.114	0.01
Trial Type	1	321	2272797.98	575931.25	1266.76	0.000	0.80
Condition	1	321	22279.26	339526.68	21.06	0.000	0.06
Condition Order x Age	2	321	56570.55	6329361.12	1.43	0.240	0.01
Condition Order x Trial Type	1	321	30.61	575931.25	0.02	0.896	0.00
Age x Trial Type	2	321	2284.81	575931.25	0.64	0.530	0.00
Condition Order x Condition	1	321	541.88	339526.68	0.51	0.475	0.00
Age x Condition	2	321	3485.63	339526.68	1.65	0.194	0.01
Trial Type x Condition	1	321	3056.77	138709.99	7.07	0.008	0.02
Condition Order x Age x Trial Type	2	321	328.71	575931.25	0.09	0.912	0.00
Condition Order x Age x Condition	2	321	12070.27	339526.68	5.71	0.004	0.03
Condition Order x Trial Type x Condition	1	321	254.5	138709.99	0.59	0.443	0.00
Age x Trial Type x Condition	2	321	6144.04	138709.99	7.11	0.001	0.04
Condition Order x Age x Trial Type x Condition	2	321	341.41	138709.99	0.4	0.674	0.00

Note. To assess proactive control, we compared baseline and proactive color naming blocks with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA conducted on diagnostic items. Age and condition order were between-subjects variables.

2.2 Color Naming ISPC Effect

Table 2: ISPC x Age Interaction for Inducer Items during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	5331.46	6167168.88	0.28	0.599	0.00
Age	2	321	247989.19	6167168.88	6.45	0.002	0.04
Trial Type	1	321	3735168.76	516146.65	2322.96	0.000	0.88
Condition	1	321	568869.7	656093.33	278.32	0.000	0.46
Condition Order x Age	2	321	21388.14	6167168.88	0.56	0.574	0.00
Condition Order x Trial Type	1	321	98.99	516146.65	0.06	0.804	0.00
Age x Trial Type	2	321	189.87	516146.65	0.06	0.943	0.00
Condition Order x Condition	1	321	2125.84	656093.33	1.04	0.309	0.00
Age x Condition	2	321	24599.21	656093.33	6.02	0.003	0.04
Trial Type x Condition	1	321	547522.13	264110.17	665.46	0.000	0.68
Condition Order x Age x Trial Type	2	321	573.16	516146.65	0.18	0.837	0.01
Condition Order x Age x Condition	2	321	4042.67	656093.33	0.99	0.373	0.01
Condition Order x Trial Type x Condition	1	321	8027.44	264110.17	9.76	0.002	0.03
Age x Trial Type x Condition	2	321	232.31	264110.17	0.14	0.868	0.00
Condition Order x Age x Trial Type x Condition	2	321	532.48	264110.17	0.32	0.724	0.00

Note. To assess reactive control, we examined the ISPC effect with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Reactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA conducted on inducer items. Age and condition order were between-subjects variables.

2.3 Color Naming Congruency Cost

Table 3.2: Proactive - Reactive Congruency Cost x Age Interaction for Diagnostic Items during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition	1	324	894.06	338435.6	0.86	0.356	0.00
Age	2	324	35754.72	3542919	1.63	0.197	0.01
Condition x Age	2	324	6415	338435.6	3.07	0.048	0.02

Note. Moreover, we contrasted the proactive and reactive conditions directly with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Proactive, Reactive) mixed-design ANOVA.

2.4 Color Naming Reactive Transfer Cost

Table 4: Reactive Transfer Cost x Age Interaction during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	12586.76	6785768	0.60	0.441	0.00
Age	2	321	155066.5	6785768	3.67	0.027	0.02
Trial Type	1	321	2093026	521271.4	1288.89	0.000	0.80
Item Type	1	321	3784.97	278109.8	4.37	0.037	0.01
Condition Order x Age	2	321	18656.45	6785768	0.44	0.644	0.00
Condition Order x Trial Type	1	321	3647.32	521271.4	2.25	0.135	0.01
Age x Trial Type	2	321	298.51	521271.4	0.09	0.912	0.00
Condition Order x Item Type	1	321	48.07	278109.8	0.06	0.814	0.00
Age x Item Type	2	321	9800.59	278109.8	5.66	0.004	0.03
Trial Type x Item Type	1	321	64525.35	179366.5	115.48	0.000	0.27
Condition Order x Age x Trial Type	2	321	3464.25	521271.4	1.07	0.345	0.01
Condition Order x Age x Item Type	2	321	1479.23	278109.8	0.85	0.427	0.01
Condition Order x Trial Type x Item Type	1	321	370.71	179366.5	0.66	0.416	0.00
Age x Trial Type x Item Type	2	321	1222.17	179366.5	1.09	0.336	0.01
Condition Order x Age x Trial Type x Item Type	2	321	346.25	179366.5	0.31	0.734	0.00

Note. We examined the transfer cost in the reactive condition, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.5 Color Naming Proactive Transfer Cost

Table 5: Proactive Transfer Cost x Age during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	67.53	7189003	0.00	0.956	0.00
Age	2	321	59868.24	7189003	1.34	0.264	0.01
Trial Type	1	321	1556329	438634.3	1138.95	0.000	0.78
Item Type	1	321	71968.42	224705.1	102.81	0.000	0.24
Condition Order x Age	2	321	121940.5	7189003	2.72	0.067	0.00
Condition Order x Trial Type	1	321	672.7	438634.3	0.49	0.483	0.00
Age x Trial Type	2	321	8590.42	438634.3	3.14	0.044	0.02
Condition Order x Item Type	1	321	184.97	224705.1	0.26	0.608	0.00
Age x Item Type	2	321	1101.12	224705.1	0.79	0.456	0.01
Trial Type x Item Type	1	321	41927.8	134444.5	100.11	0.000	0.24
Condition Order x Age x Trial Type	2	321	2710.61	438634.3	0.99	0.372	0.01
Condition Order x Age x Item Type	2	321	1514.64	224705.1	1.08	0.340	0.01
Condition Order x Trial Type x Item Type	1	321	19.81	134444.5	0.05	0.828	0.00
Age x Trial Type x Item Type	2	321	487.29	134444.5	0.58	0.560	0.00
Condition Order x Age x Trial Type x Item Type	2	321	2503.56	134444.5	2.99	0.052	0.02

Note. We next examined transfer cost in the proactive condition, with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.6 Color Naming Proactive - Reactive Transfer Cost

Table 6: Proactive - Reactive Transfer Cost x Age Interaction during Color Naming Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	5405.23	13053994	0.13	0.716	0.00
Age	2	321	202263.1	13053994	2.49	0.085	0.02
Trial Type	1	321	3629515	799277.3	1457.66	0.000	0.82
Item Type	1	321	54381.18	320655.4	54.44	0.000	0.15
Condition	1	321	71914.55	920776.5	25.07	0.000	0.07
Condition Order x Age	2	321	90366.33	13053994	1.11	0.330	0.01
Condition Order x Trial Type	1	321	593.62	799277.3	0.24	0.626	0.00
Age x Trial Type	2	321	3138.74	799277.3	0.63	0.533	0.00
Condition Order x Item Type	1	321	22.23	320655.4	0.02	0.882	0.00
Age x Item Type	2	321	3875.44	320655.4	1.94	0.145	0.01
Condition Order x Condition	1	321	7249.06	920776.5	2.53	0.113	0.01
Age x Condition	2	321	12671.73	920776.5	2.21	0.111	0.01
Trial Type x Item Type	1	321	105240.1	180146.9	187.53	0.000	0.37
Trial Type x Condition	1	321	19840.35	160628.4	39.65	0.000	0.11
Item Type x Condition	1	321	21372.21	182159.5	37.66	0.000	0.11
Condition Order x Age x Trial Type	2	321	381.3	799277.3	0.08	0.926	0.00
Condition Order x Age x Item Type	2	321	1331.74	320655.4	0.67	0.514	0.00
Condition Order x Age x Condition	2	321	50230.57	920776.5	8.76	0.000	0.05
Condition Order x Trial Type x Item Type	1	321	109.57	180146.9	0.20	0.659	0.00
Age x Trial Type x Item Type	2	321	117.41	180146.9	0.10	0.901	0.00
Condition Order x Trial Type x Condition	1	321	3726.4	160628.4	7.45	0.007	0.02
Age x Trial Type x Condition	2	321	5750.18	160628.4	5.75	0.004	0.04
Condition Order x Item Type x Condition	1	321	210.81	182159.5	0.37	0.543	0.00
Age x Item Type x Condition	2	321	7026.27	182159.5	6.19	0.002	0.04
Trial Type x Item Type x Condition	1	321	1213.06	133664.1	2.91	0.089	0.01
Condition Order x Age x Trial Type x Item Type	2	321	2137.48	180146.9	1.90	0.151	0.01
Condition Order x Age x Trial Type x Condition	2	321	5793.56	160628.4	5.79	0.003	0.04
Condition Order x Age x Item Type x Condition	2	321	1662.13	182159.5	1.46	0.233	0.01
Condition Order x Trial Type x Item Type x Condition	1	321	280.95	133664.1	0.67	0.412	0.00
Age x Trial Type x Item Type x Condition	2	321	1592.04	133664.1	1.91	0.150	0.01
Condition Order x Age x Trial Type x Item Type x Condition	2	321	712.33	133664.1	0.86	0.426	0.01

Note. We also ran a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Reactive, Proactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.7 Word Reading LWPC Effect

Table 7: LWPC x Age Interaction for Diagnostic Items during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	131.67	7391858.95	0.01	0.940	0.00
Age	2	321	39817.8	7391858.95	0.86	0.422	0.01
Trial Type	1	321	93338.12	268777.06	111.47	0.000	0.26
Condition	1	321	37670.17	684257.79	17.67	0.000	0.01
Condition Order x Age	2	321	53145.8	7391858.95	1.15	0.317	0.01
Condition Order x Trial Type	1	321	361.92	268777.06	0.43	0.511	0.00
Age x Trial Type	2	321	743.34	268777.06	0.44	0.642	0.00
Condition Order x Condition	1	321	20924.96	684257.79	9.82	0.002	0.03
Age x Condition	2	321	5805.12	684257.79	1.36	0.258	0.01
Trial Type x Condition	1	321	602.19	215362.63	0.90	0.344	0.00
Condition Order x Age x Trial Type	2	321	1868.75	268777.06	1.12	0.329	0.01
Condition Order x Age x Condition	2	321	7558.94	684257.79	1.77	0.171	0.01
Condition Order x Trial Type x Condition	1	321	375.76	215362.63	0.56	0.455	0.00
Age x Trial Type x Condition	2	321	3381.4	215362.63	2.52	0.082	0.02
Condition Order x Age x Trial Type x Condition	2	321	174.17	215362.63	0.13	0.878	0.00

Note. We compared the baseline and proactive word reading blocks using diagnostic items, with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.8 Word Reading ISPC Effect

Table 8: ISPC x Age Interaction for Diagnostic Items during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	13312.32	7643047.65	0.56	0.455	0.00
Age	2	321	38477.05	7643047.65	0.81	0.447	0.01
Trial Type	1	321	63911.88	244110.74	84.04	0.000	0.21
Condition	1	321	14348.2	797900.1	5.77	0.017	0.02
Condition Order x Age	2	321	4798.13	7643047.65	0.10	0.904	0.00
Condition Order x Trial Type	1	321	183.73	244110.74	0.24	0.623	0.00
Age x Trial Type	2	321	2252.67	244110.74	1.48	0.229	0.01
Condition Order x Condition	1	321	593.56	797900.1	0.24	0.625	0.00
Age x Condition	2	321	3301.29	797900.1	0.66	0.515	0.00
Trial Type x Condition	1	321	1203.8	198443.1	1.95	0.164	0.01
Condition Order x Age x Trial Type	2	321	101.88	244110.74	0.07	0.935	0.00
Condition Order x Age x Condition	2	321	4650.53	797900.1	0.94	0.393	0.01
Condition Order x Trial Type x Condition	1	321	65.19	198443.1	0.11	0.746	0.00
Age x Trial Type x Condition	2	321	1357.63	198443.1	1.10	0.335	0.01
Condition Order x Age x Trial Type x Condition	2	321	270.37	198443.1	0.22	0.804	0.00

Note. We compared the baseline and reactive word reading blocks using inducer items, with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Reactive Control) x 2 (Trial Type: Congruent, Incongruent) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.9 Word Reading Congruency Cost

Table 9: Proactive - Reactive Congruency Cost x Age Interaction for Diagnostic Items during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition	1	324	1575.58	494602.6	1.03	0.31	0.00
Age	2	324	20954.32	3652440	0.93	0.396	0.01
Condition x Age	2	324	1275.07	494602.6	0.42	0.659	0.00

Note. Moreover, we contrasted the proactive and reactive conditions directly with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Proactive, Reactive) mixed-design ANOVA.

2.10 Word Reading Reactive Transfer Cost

Table 10: Reactive Transfer Cost x Age Interaction during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	34382.73	8162896	1.35	0.246	0.00
Age	2	321	41828.19	8162896	0.82	0.440	0.01
Trial Type	1	321	75382.11	276214.1	87.60	0.000	0.21
Item Type	1	321	3819.22	293398.6	4.18	0.042	0.01
Condition Order x Age	2	321	2277.03	8162896	0.04	0.956	0.00
Condition Order x Trial Type	1	321	0.03	276214.1	0.00	0.995	0.00
Age x Trial Type	2	321	1120.34	276214.1	0.65	0.522	0.00
Condition Order x Item Type	1	321	2087.01	293398.6	2.28	0.132	0.01
Age x Item Type	2	321	1826.37	293398.6	1.00	0.369	0.01
Trial Type x Item Type	1	321	3186.13	230518.7	4.44	0.036	0.01
Condition Order x Age x Trial Type	2	321	214.01	276214.1	0.12	0.883	0.00
Condition Order x Age x Item Type	2	321	690.26	293398.6	0.38	0.686	0.00
Condition Order x Trial Type x Item Type	1	321	32.11	230518.7	0.04	0.833	0.00
Age x Trial Type x Item Type	2	321	289.79	230518.7	0.20	0.817	0.00
Condition Order x Age x Trial Type x Item Type	2	321	967.05	230518.7	0.67	0.511	0.00

Note. We examined the reactive transfer cost for the word reading blocks, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.11 Word Reading Proactive Transfer Cost

Table 11: Proactive Transfer Cost x Age Interaction during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	46864.04	7953207	1.89	0.170	0.01
Age	2	321	10532.59	7953207	0.21	0.809	0.00
Trial Type	1	321	53252.89	189651.5	90.13	0.000	0.22
Item Type	1	321	368.7	228111.9	0.52	0.472	0.00
Condition Order x Age	2	321	97664.44	7953207	1.97	0.141	0.01
Condition Order x Trial Type	1	321	3228.59	189651.5	5.46	0.020	0.02
Age x Trial Type	2	321	1994.27	189651.5	1.69	0.187	0.01
Condition Order x Item Type	1	321	3642.3	228111.9	5.13	0.024	0.02
Age x Item Type	2	321	978.29	228111.9	0.69	0.503	0.00
Trial Type x Item Type	1	321	2520.79	173641.1	4.66	0.032	0.01
Condition Order x Age x Trial Type	2	321	1267.12	189651.5	1.07	0.343	0.01
Condition Order x Age x Item Type	2	321	409.6	228111.9	0.29	0.750	0.00
Condition Order x Trial Type x Item Type	1	321	339.01	173641.1	0.63	0.429	0.00
Age x Trial Type x Item Type	2	321	225.45	173641.1	0.21	0.812	0.00
Condition Order x Age x Trial Type x Item Type	2	321	467.7	173641.1	0.43	0.649	0.00

Note. We also examined the proactive transfer cost for the word reading blocks, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.12 Word Reading Proactive - Reactive Transfer Cost

Table 12: Proactive - Reactive Transfer Cost x Age Interaction during Word Reading Blocks

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition Order	1	321	482.21	14756676	0.01	0.918	0.00
Age	2	321	46978.7	14756676	0.51	0.600	0.00
Trial Type	1	321	127676.1	269802.2	151.90	0.000	0.32
Item Type	1	321	907.31	294169	0.99	0.320	0.00
Condition	1	321	4849.11	1359427	1.15	0.285	0.00
Condition Order x Age	2	321	44639.44	14756676	0.49	0.616	0.00
Condition Order x Trial Type	1	321	1624.9	269802.2	1.93	0.165	0.01
Age x Trial Type	2	321	3023.88	269802.2	1.80	0.167	0.01
Condition Order x Item Type	1	321	5621.73	294169	6.13	0.014	0.02
Age x Item Type	2	321	2660.33	294169	1.45	0.236	0.01
Condition Order x Condition	1	321	80764.55	1359427	19.07	0.000	0.06
Age x Condition	2	321	5382.08	1359427	0.64	0.530	0.00
Trial Type x Item Type	1	321	5687.46	204594.9	8.92	0.003	0.03
Trial Type x Condition	1	321	958.88	196063.3	1.57	0.211	0.01
Item Type x Condition	1	321	3280.61	227341.4	4.63	0.032	0.01
Condition Order x Age x Trial Type	2	321	1255.69	269802.2	0.75	0.475	0.01
Condition Order x Age x Item Type	2	321	687.38	294169	0.38	0.688	0.00
Condition Order x Age x Condition	2	321	55302.03	1359427	6.53	0.002	0.04
Condition Order x Trial Type x Item Type	1	321	81.22	204594.9	0.13	0.721	0.00
Age x Trial Type x Item Type	2	321	229.98	204594.9	0.18	0.835	0.00
Condition Order x Trial Type x Condition	1	321	1603.72	196063.3	2.63	0.106	0.01
Age x Trial Type x Condition	2	321	90.73	196063.3	0.07	0.928	0.00
Condition Order x Item Type x Condition	1	321	107.57	227341.4	0.15	0.697	0.00
Age x Item Type x Condition	2	321	144.33	227341.4	0.10	0.903	0.00
Trial Type x Item Type x Condition	1	321	19.46	199564.8	0.03	0.860	0.00
Condition Order x Age x Trial Type x Item Type	2	321	1378.77	204594.9	1.08	0.340	0.01
Condition Order x Age x Trial Type x Condition	2	321	225.45	196063.3	0.18	0.832	0.00
Condition Order x Age x Item Type x Condition	2	321	412.48	227341.4	0.29	0.748	0.00
Condition Order x Trial Type x Item Type x Condition	1	321	289.9	199564.8	0.47	0.495	0.00
Age x Trial Type x Item Type x Condition	2	321	285.26	199564.8	0.23	0.795	0.00
Condition Order x Age x Trial Type x Item Type x Condition	2	321	55.99	199564.8	0.05	0.956	0.00

Note. We also ran a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Reactive, Proactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) x 2 (Condition Order: Proactive-Baseline-Reactive, Reactive-Baseline-Proactive) mixed-design ANOVA.

2.13 Color Naming Cost for Proactive - Baseline Mode

Table 13: Color Naming Cost x Age Interaction for Congruent Diagnostic Items

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition	1	324	2687.08	526841.40	1.65	0.200	0.01
Age	2	324	89413.64	1542171.93	9.39	0.000	0.06
Condition x Age	2	324	20696.45	526841.40	6.36	0.002	0.04

Note. To compare color naming cost (i.e., the RT difference between color naming and word reading blocks) across proactive and baseline conditions, we ran a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Proactive) mixed-design ANOVA using congruent diagnostic trials.

2.14 Color Naming Cost for Proactive - Reactive Mode

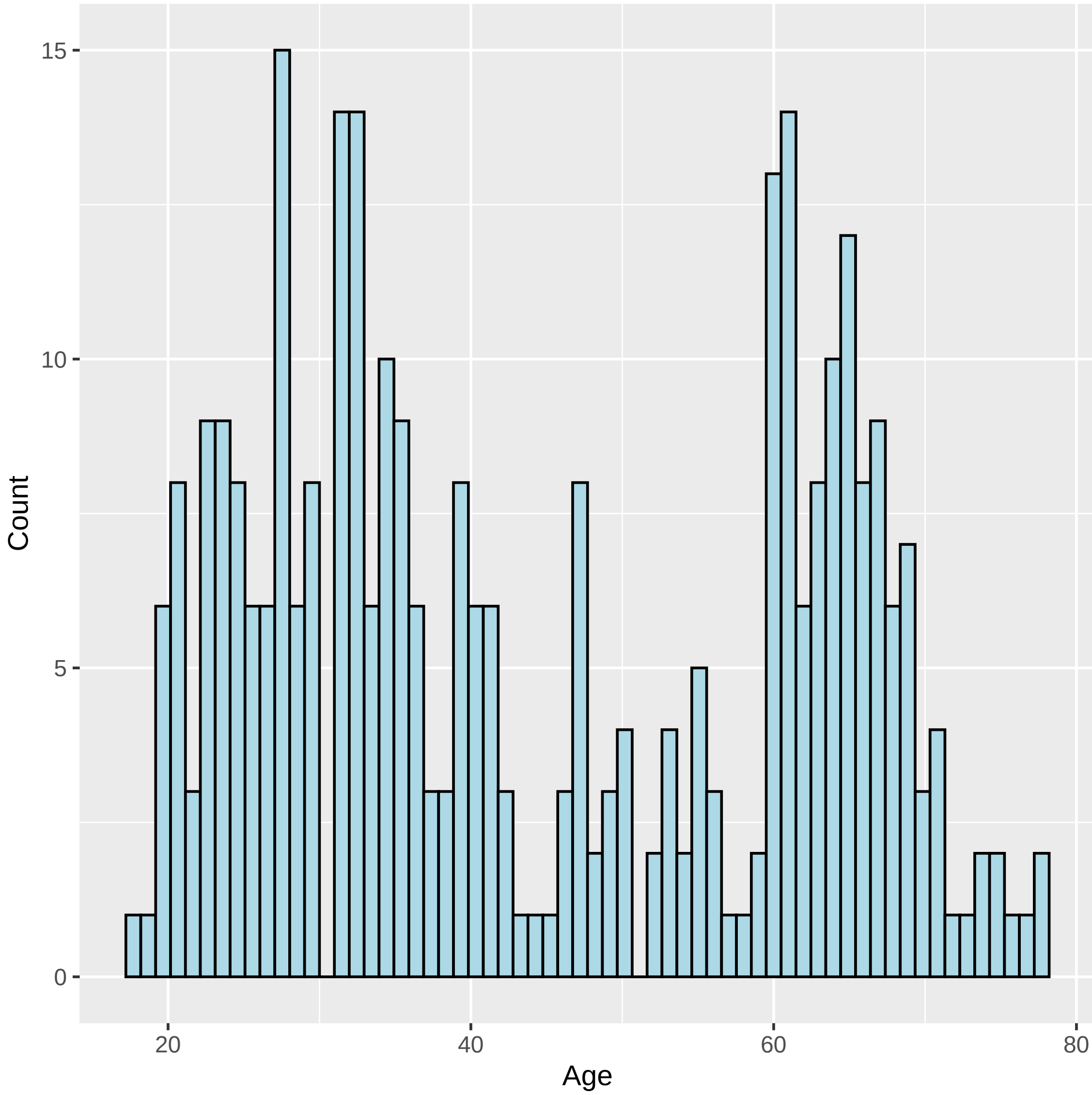
Table 14: Color Naming Cost x Age Interaction for Congruent Diagnostic Items

Predictor	df_{Num}	df_{Den}	SS_{Num}	SS_{Den}	F	p	η^2_p
Condition	1	324	4843.39	571479.22	2.75	.098	0.01
Age	2	324	93073.48	1593698.23	9.46	.000	0.06
Condition x Age	2	324	12356.78	571479.22	3.50	.031	0.02

Note. To compare color naming cost (i.e., the RT difference between color naming and word reading blocks) across proactive and reactive conditions, we ran a 3 x (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Reactive, Proactive) mixed-design ANOVA using congruent diagnostic trials.

3 Full Linear Mixed-Effect Model Results

3.1 Age Histogram



The age distribution of our sample. While we operationalized age as a continuous predictor for the below linear mixed-effect models, to further substantiate our earlier findings on the relationship between age and cognitive control across the lifespan, this histogram indicates that the data may not be ideally suited for such a choice. Indeed, although we were able to recruit balanced numbers across our three pre-defined age categories for robust comparisons across different life stages, we can clearly see there is a relatively less uniform distribution within the middle-aged category. This distribution is likely the result of not imposing constraints on the overall shape of the age distribution via stratified sampling, but rather recruiting within each group based on participant availability and self-selection into the study. For this reason, we made the decision to include the following analyses to this supplementary document instead of the actual manuscript.

3.2 Color Naming LWPC Effect

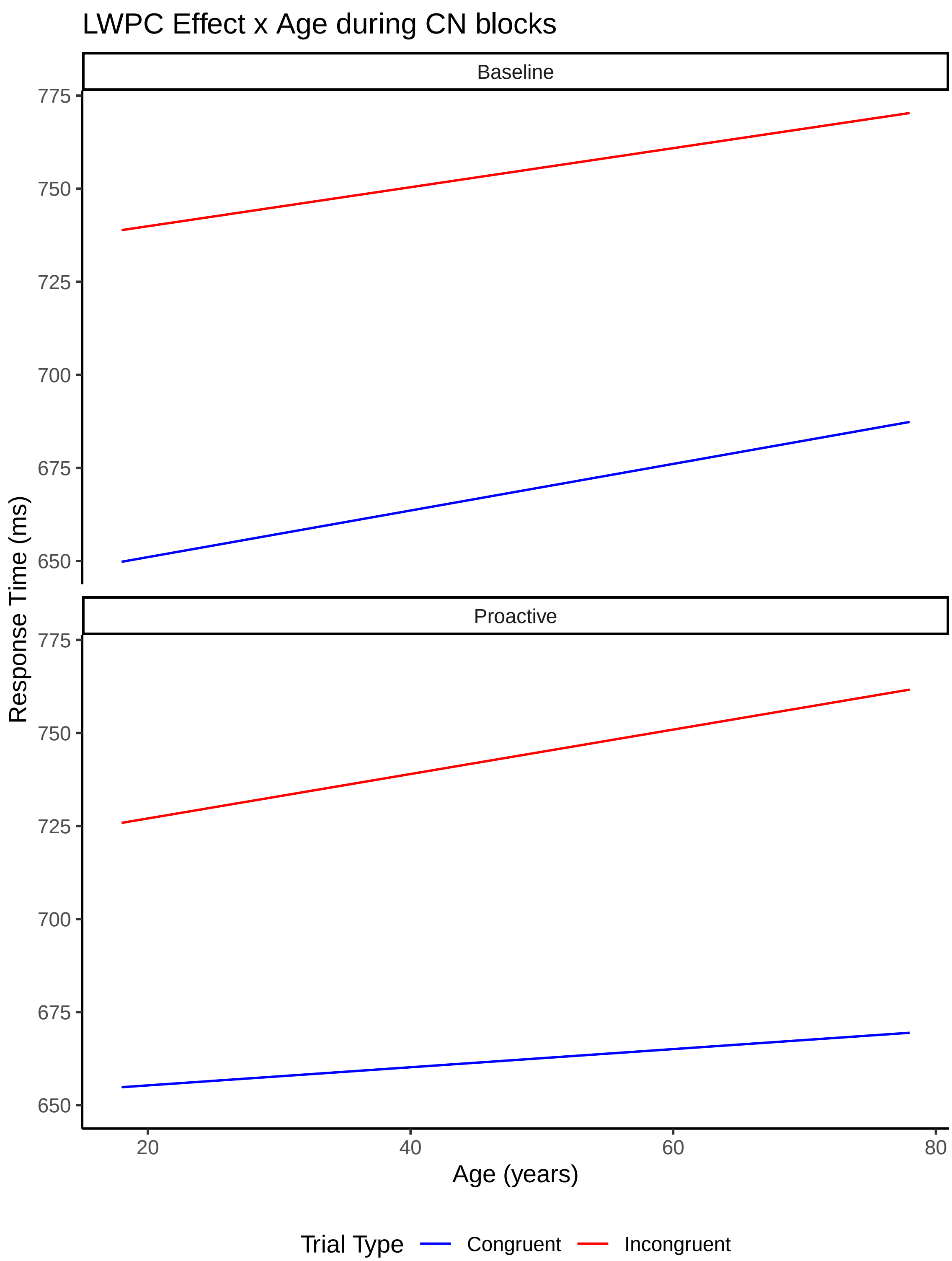
$$RT = mode\ x\ con\ x\ age + \left(1 + mode\ x\ con \mid ID\right)$$

Table 1: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
Intercept	638.49	[615.49, 661.49]	54.40	324	< .001
ConIncongruent	90.92	[76.05, 105.80]	11.98	322	< .001
ModeProactive	11.97	[-0.62, 24.55]	1.86	321	.063
Age	0.63	[0.15, 1.11]	2.56	325	.011
ConIncongruent × ModeProactive	-26.28	[-38.95, -13.61]	-4.06	322	< .001
ConIncongruent × Age	-0.10	[-0.41, 0.21]	-0.64	324	.521
ModeProactive × Age	-0.38	[-0.65, -0.12]	-2.85	322	.005
ConIncongruent × ModeProactive × Age	0.45	[0.19, 0.72]	3.37	322	< .001

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ModeProactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the LWPC effect, is represented by the two-way interaction term 'ConIncongruent x ModeProactive' and is significant (β = -26.28 ms, CI = [-38.95, -13.61], t = -4.06, p < .001). Its relationship with age is represented by the three-way interaction term 'ConIncongruent x ModeProactive x Age' and is also significant (β = .45 ms, CI = [.19, .72], t = 3.37, p < .001). The age in which the LWPC effect goes to zero is computed by dividing the effect over its interaction with age, equaling 58.4 years old.


LWPC Effect x Age during CN blocks
Baseline
Proactive
Response Time (ms)
775
750
725
700
675
650
20
40
60
80
Age (years)
Trial Type
Congruent
Incongruent

3.3 Color Naming ISPC Effect

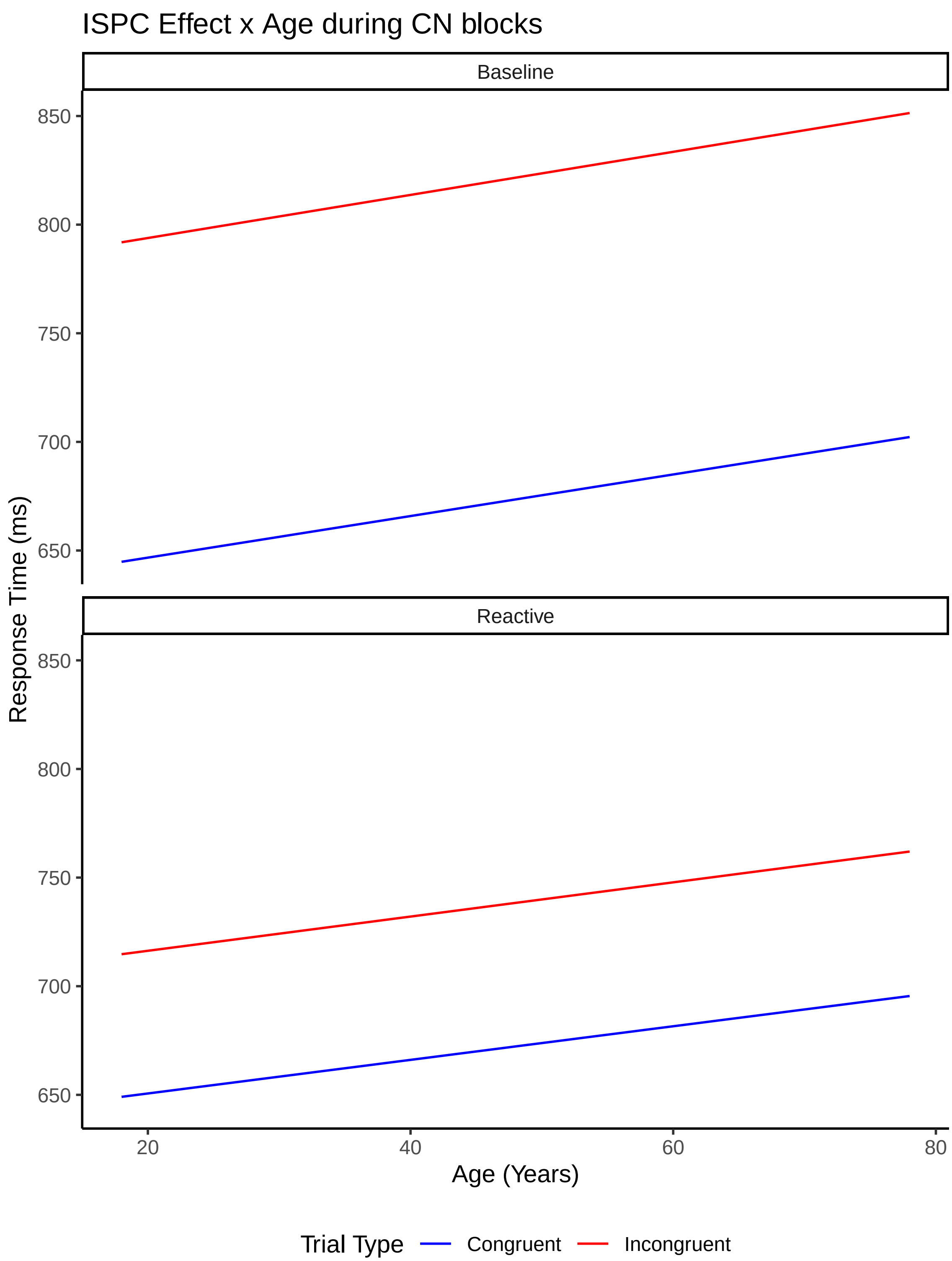
$$RT = mode\ x\ con\ x\ age + \left(1 + mode\ x\ con \mid ID\right)$$

Table 2: ISPC x Age Interaction for Inducer Items during Color Naming Blocks

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
Intercept	627.58	[604.93, 650.22]	54.31	325	< .001
ConIncongruent	146.43	[131.75, 161.10]	19.56	315	< .001
ModeReactive	7.58	[-8.91, 24.07]	0.90	320	.368
Age	0.96	[0.48, 1.43]	3.97	325	< .001
ConIncongruent × ModeReactive	-81.03	[-98.30, -63.77]	-9.20	319	< .001
ConIncongruent × Age	0.03	[-0.27, 0.34]	0.22	323	.825
ModeReactive × Age	-0.18	[-0.53, 0.16]	-1.05	320	.297
ConIncongruent × ModeReactive × Age	-0.02	[-0.38, 0.34]	-0.11	326	.911

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ModeReactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the ISPC effect, is represented by the two-way interaction term 'ConIncongruent x ModeReactive' and is significant (β = -81.03 ms, CI = [-98.30, -63.77], t = -9.20, p < .001). Its interaction with age is represented by the term 'ConIncongruent x ModeReactive x Age' and is not significant (β = -.02 ms, CI = [-.38, .34], t = -.11, p =.911).


ISPC Effect x Age during CN blocks
Baseline
Reactive
Response Time (ms)
850
800
750
700
650
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.4 Color Naming Congruency Cost

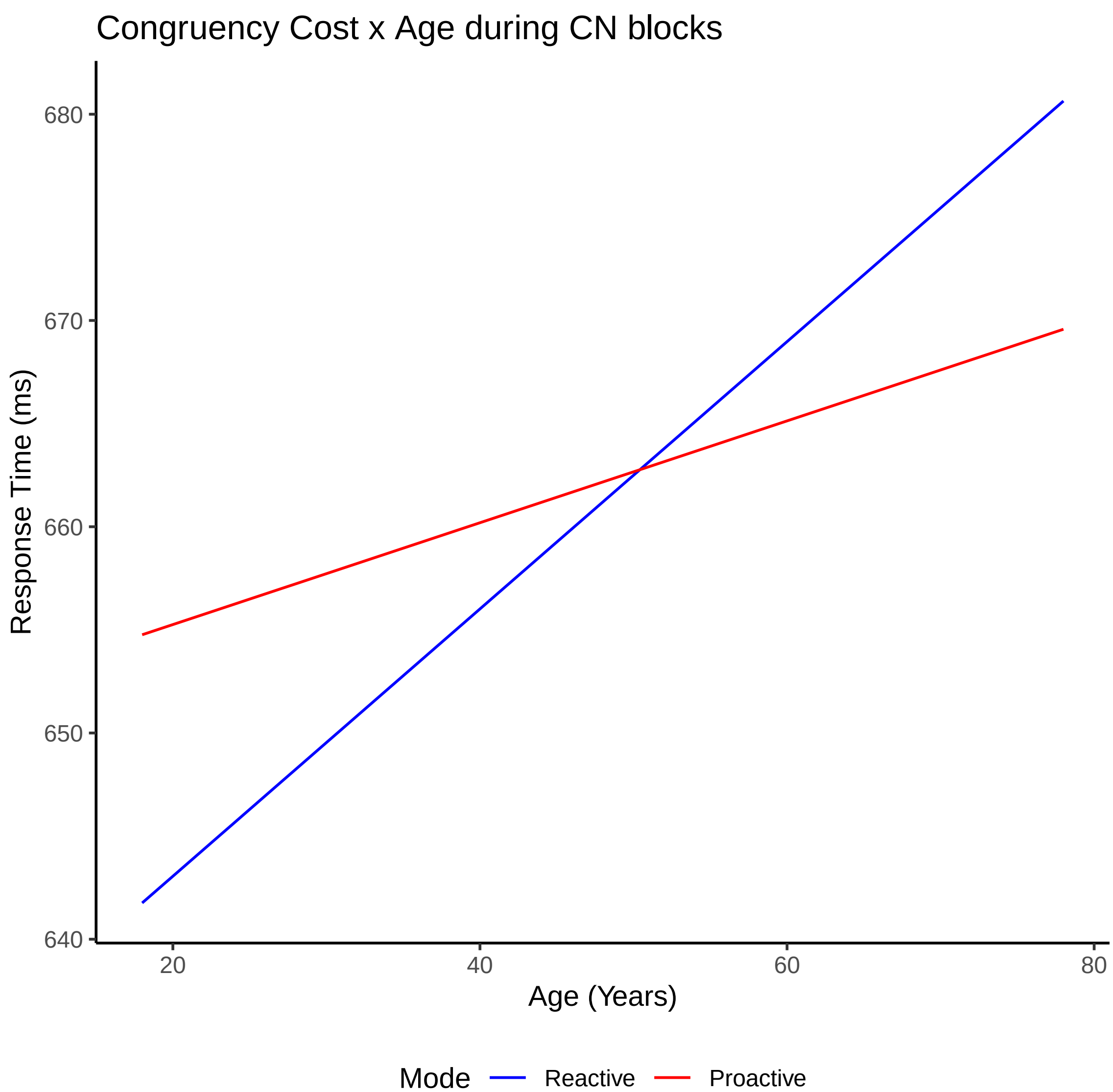
$$RT = mode\ x\ age + \left(1 + mode \mid ID\right)$$

Table 3: Congruency Cost x Age Interaction for Diagnostic Items during Color Naming blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	630.09	[606.74, 653.45]	52.88	325	< .001
ModeProactive	20.22	[6.46, 33.99]	2.88	319	.004
Age	0.65	[0.16, 1.14]	2.61	325	.010
ModeProactive × Age	-0.40	[-0.69, -0.11]	-2.74	319	.007

Note. ModeProactive refers to the effect of Condition, with Reactive treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the congruency cost, is represented by the term 'ModeProactive' and is significant (β = 20.22 ms, CI = [6.46, 33.99], t = 2.88, p = .004). Its interaction with age is represented by the two-way interaction term 'ModeProactive x Age' and is also significant (β = -.40 ms, CI = [-.69, -.11], t = -2.74, p = .007). The age in which the congruency cost goes to zero is computed by dividing the effect over its interaction with age, equaling 50.6 years old.


Congruency Cost x Age during CN blocks
Response Time (ms)
680
670
660
650
640
20
40
60
80
Age (Years)
Mode
Reactive
Proactive

3.5 Color Naming Reactive Transfer Cost

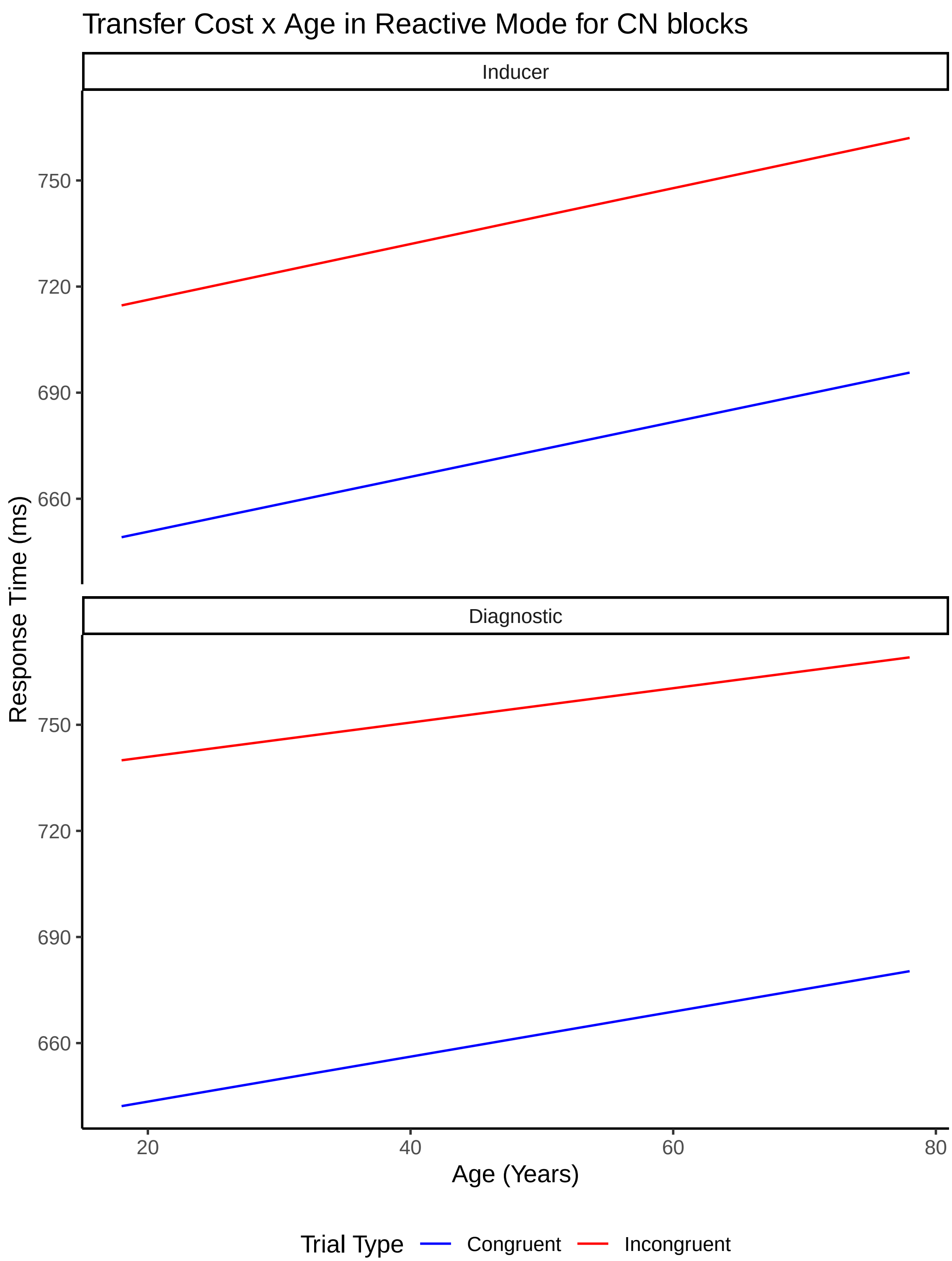
$$RT = con\ x\ item\ x\ age + \left(1 + con\ x\ item \mid ID\right)$$

Table 4: Reactive Transfer Cost x Age Interaction during Color Naming blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	635.16	[609.57, 660.76]	48.64	324	< .001
ItemDiagnostic	-4.43	[-16.61, 7.75]	-0.71	315	.476
ConIncongruent	65.30	[50.34, 80.26]	8.56	321	< .001
Age	0.78	[0.24, 1.31]	2.85	324	.005
ItemDiagnostic × ConIncongruent	35.20	[21.02, 49.38]	4.87	318	< .001
ItemDiagnostic × Age	-0.14	[-0.39, 0.11]	-1.08	316	.282
ConIncongruent × Age	0.01	[-0.30, 0.33]	0.09	321	.932
ItemDiagnostic × ConIncongruent × Age	-0.16	[-0.46, 0.13]	-1.09	318	.277

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the transfer cost in the reactive mode, is represented by the two-way interaction term 'ItemDiagnostic x ConIncongruent' and is significant (β = 35.20 ms, CI = [21.02, 49.38], t = 4.87, p < .001). Its interaction with age is represented by the three-way interaction term 'ItemDiagnostic x ConIncongruent x Age' and is not significant (β = -.16 ms, CI = [-.46, .13], t = -1.09, p = .277).


Transfer Cost x Age in Reactive Mode for CN blocks
Inducer
Diagnostic
Response Time (ms)
750
720
690
660
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.6 Color Naming Proactive Transfer Cost

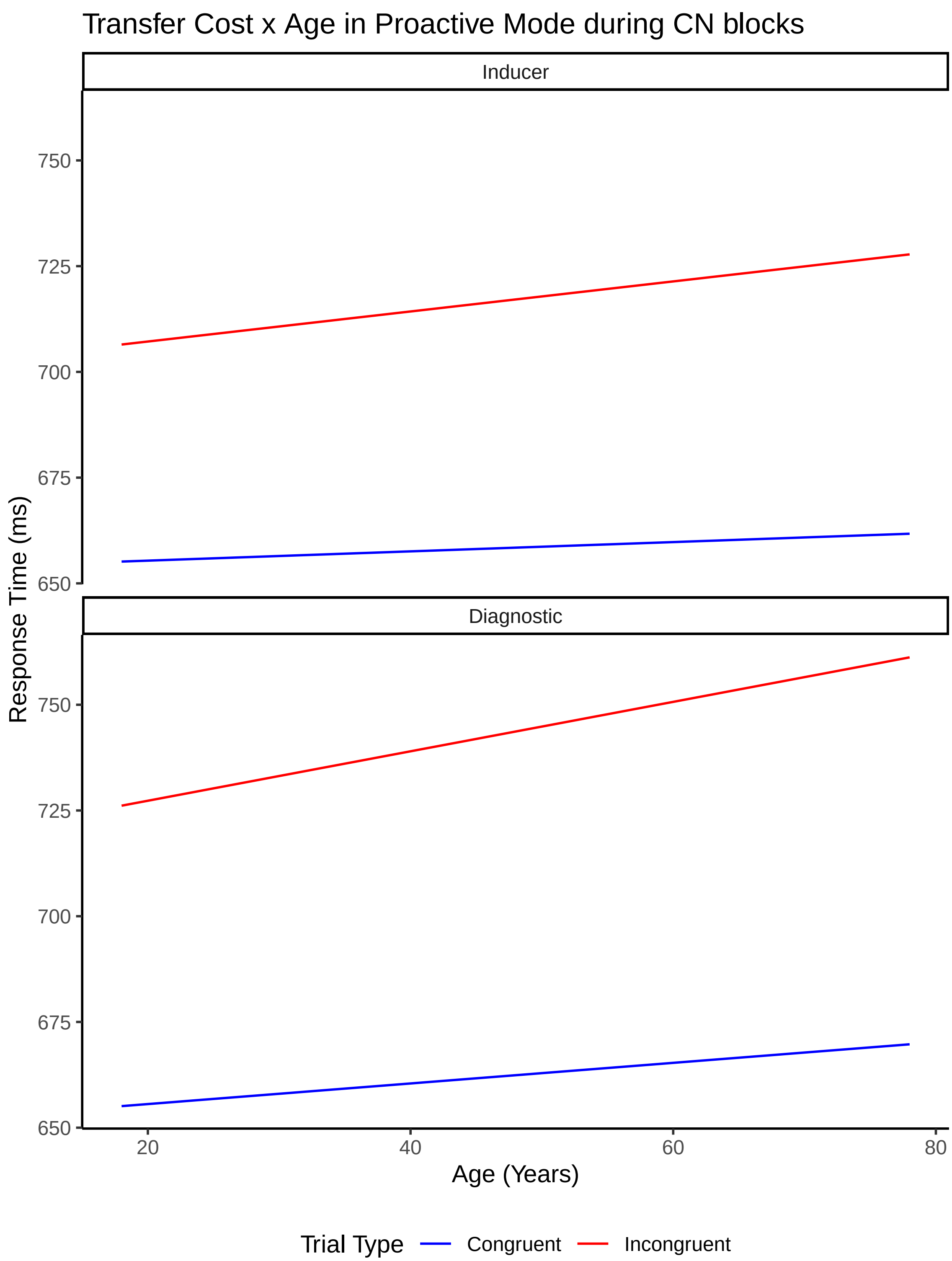
$$RT = \; con\; x\; item\; x\; age + \left(1 + \; con\; x\; item \mid ID\right)$$

Table 5: Proactive Transfer Cost x Age Interaction during Color Naming blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	653.18	[627.23, 679.12]	49.35	324	< .001
ItemDiagnostic	-2.46	[-12.53, 7.61]	-0.48	316	.632
ConIncongruent	46.90	[34.92, 58.88]	7.67	324	< .001
Age	0.11	[-0.43, 0.65]	0.40	324	.691
ItemDiagnostic × ConIncongruent	18.00	[5.80, 30.21]	2.89	314	.004
ItemDiagnostic × Age	0.13	[-0.08, 0.34]	1.25	315	.212
ConIncongruent × Age	0.25	[0.00, 0.50]	1.93	323	.055
ItemDiagnostic × ConIncongruent × Age	0.10	[-0.16, 0.35]	0.74	312	.463

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the transfer cost in the proactive mode, is represented by the two-way interaction term 'Item idDiagnostic x Con idIncongruent' and is significant (β = 18 ms, CI = [5.80, 30.21], t = 2.89, p = .004). Its interaction with age is represented by the three-way interaction term 'Item idDiagnostic x Con idIncongruent x Age' and is not significant (β = .10 ms, CI = [-.16, .35], t = .74, p = .463).



Transfer Cost x Age in Proactive Mode during CN blocks
Inducer
Diagnostic
Response Time (ms)
750
725
700
675
650
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.7 Color Naming Proactive - Reactive Transfer Cost

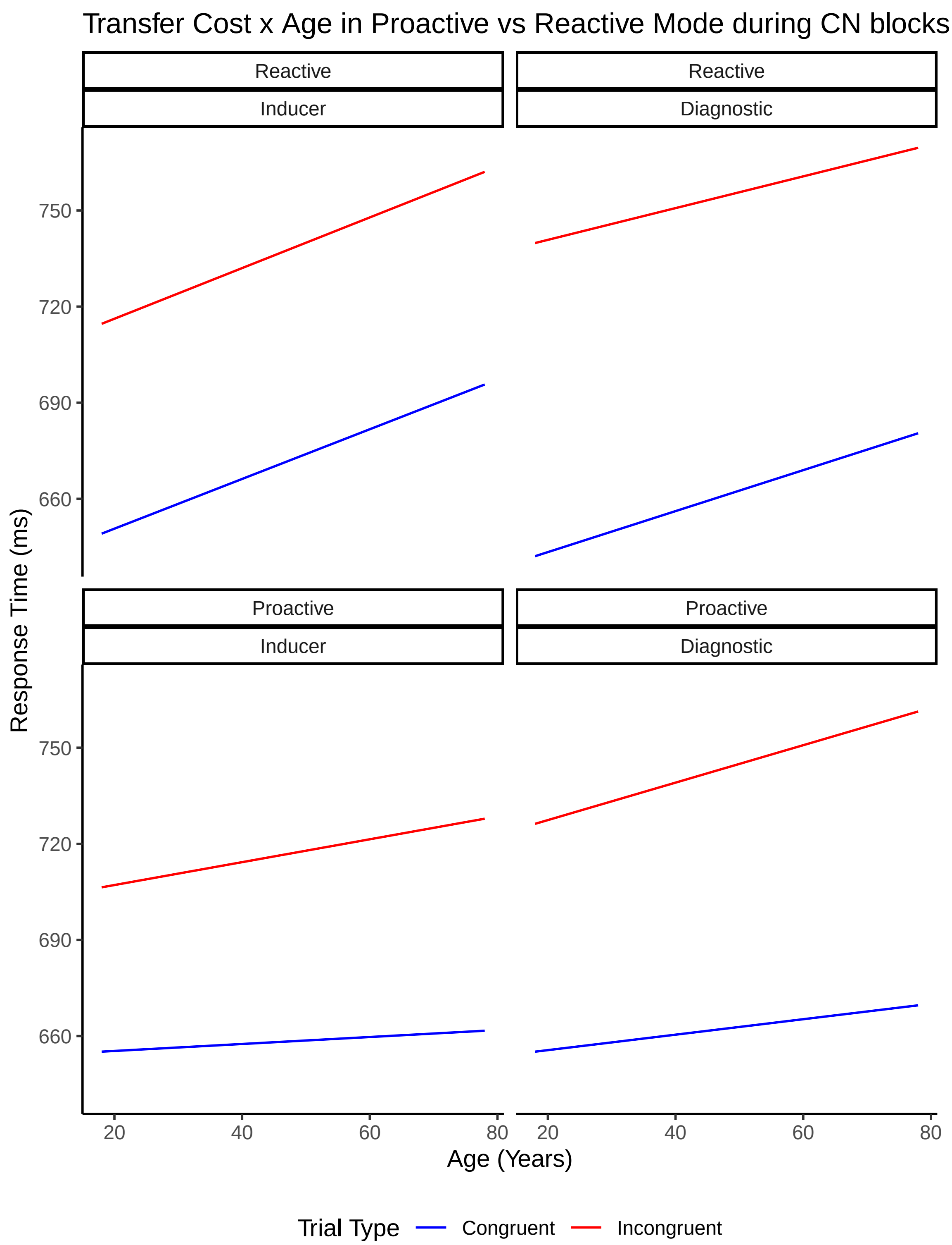
$$RT = con\ x\ item\ x\ mode\ x\ age + \left(1 + con\ x\ item\ x\ mode \mid ID\right)$$

Table 6: Proactive - Reactive Transfer Cost x Age Interaction during Color Naming blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	635.16	[609.56, 660.75]	48.64	76341	< .001
ItemDiagnostic	-4.59	[-16.90, 7.73]	-0.73	76341	.465
ConIncongruent	65.23	[50.28, 80.18]	8.55	76341	< .001
ModeProactive	18.01	[0.51, 35.52]	2.02	76341	.044
Age	0.78	[0.24, 1.31]	2.85	325	.005
ItemDiagnostic × ConIncongruent	35.11	[20.58, 49.64]	4.74	76341	< .001
ItemDiagnostic × ModeProactive	2.20	[-12.85, 17.24]	0.29	76341	.775
ConIncongruent × ModeProactive	-18.40	[-32.28, -4.53]	-2.60	76341	.009
ItemDiagnostic × Age	-0.14	[-0.39, 0.12]	-1.04	76341	.299
ConIncongruent × Age	0.01	[-0.30, 0.33]	0.09	76341	.926
ModeProactive × Age	-0.67	[-1.03, -0.30]	-3.58	76341	< .001
ItemDiagnostic × ConIncongruent × ModeProactive	-16.99	[-35.64, 1.66]	-1.79	76341	.074
ItemDiagnostic × ConIncongruent × Age	-0.16	[-0.46, 0.14]	-1.03	76341	.305
ItemDiagnostic × ModeProactive × Age	0.27	[-0.05, 0.58]	1.68	76341	.093
ConIncongruent × ModeProactive × Age	0.23	[-0.06, 0.52]	1.58	76341	.114
ItemDiagnostic × ConIncongruent × ModeProactive × Age	0.25	[-0.13, 0.64]	1.28	76341	.201

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). ModeProactive refers to the Condition effect, with Reactive treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the difference in transfer cost between modes, is represented by the 3-way interaction term 'ItemDiagnostic x ConIncongruent x ModeProactive' and is not significant (β = -16.99 ms, CI = [-35.64, 1.66], t = -1.79, p = .074). Its interaction with age is represented by the four-way interaction term 'ItemDiagnostic x ConIncongruent x ModeProactive x Age' and is not significant either (β = .25 ms, CI = [-.13, .64], t = 1.28, p = .201).


Transfer Cost x Age in Proactive vs Reactive Mode during CN blocks
Reactive
Inducer
Reactive
Diagnostic
Proactive
Inducer
Proactive
Diagnostic
Response Time (ms)
750
720
690
660
750
720
690
660
20
40
60
80
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.8 Word Reading LWPC Effect

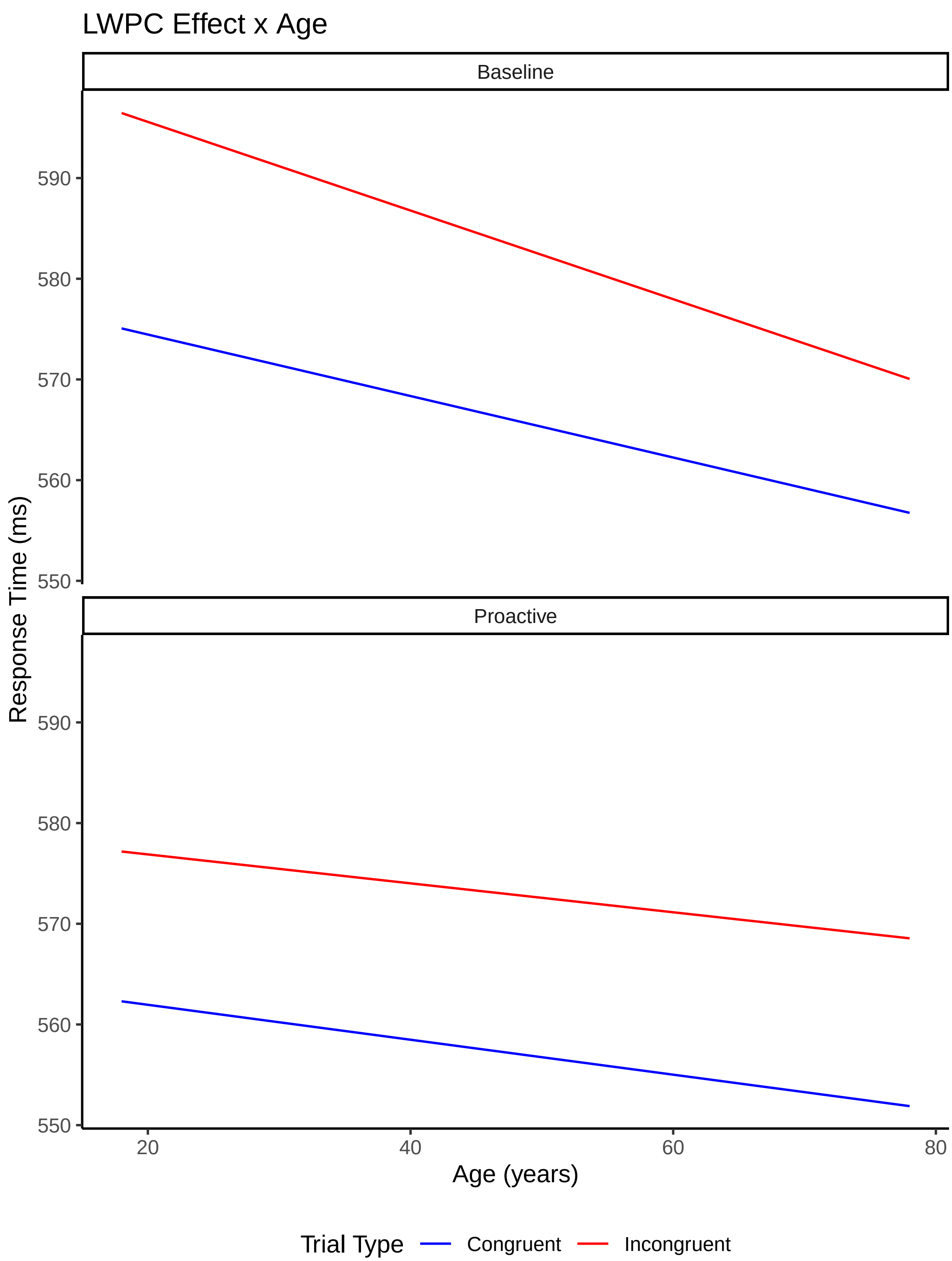
$$RT = mode\ x\ con\ x\ age + \left(1 + mode\ x\ con \mid ID\right)$$

Table 7: LWPC x Age Interaction for Diagnostic Items during Word Reading blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	580.57	[556.75, 604.38]	47.79	14761	< .001
ModeProactive	-15.14	[-30.56, 0.28]	-1.93	14761	.054
ConIncongruent	23.82	[11.66, 35.97]	3.84	14761	< .001
Age	-0.31	[-0.80, 0.19]	-1.20	325	.229
ModeProactive × ConIncongruent	-9.48	[-25.76, 6.81]	-1.14	14761	.254
ModeProactive × Age	0.13	[-0.19, 0.45]	0.80	14761	.422
ConIncongruent × Age	-0.13	[-0.39, 0.12]	-1.04	14761	.298
ModeProactive × ConIncongruent × Age	0.16	[-0.17, 0.50]	0.95	14761	.342

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ModeProactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the LWPC effect, is represented by the two-way interaction term 'ConIncongruent x ModeProactive' and is not significant (β = -9.48 ms, CI = [-25.76, 6.80], t = -1.14, p = .254). Its relationship with age is represented by the three-way interaction term 'ConIncongruent x ModeProactive x Age' and is also not significant (β = .16 ms, CI = [-.17, .50], t = .95, p = .342).


LWPC Effect x Age
Baseline
Proactive
Response Time (ms)
550
560
570
580
590
20
40
60
80
Age (years)
Trial Type
Congruent
Incongruent

3.9 Word Reading ISPC Effect

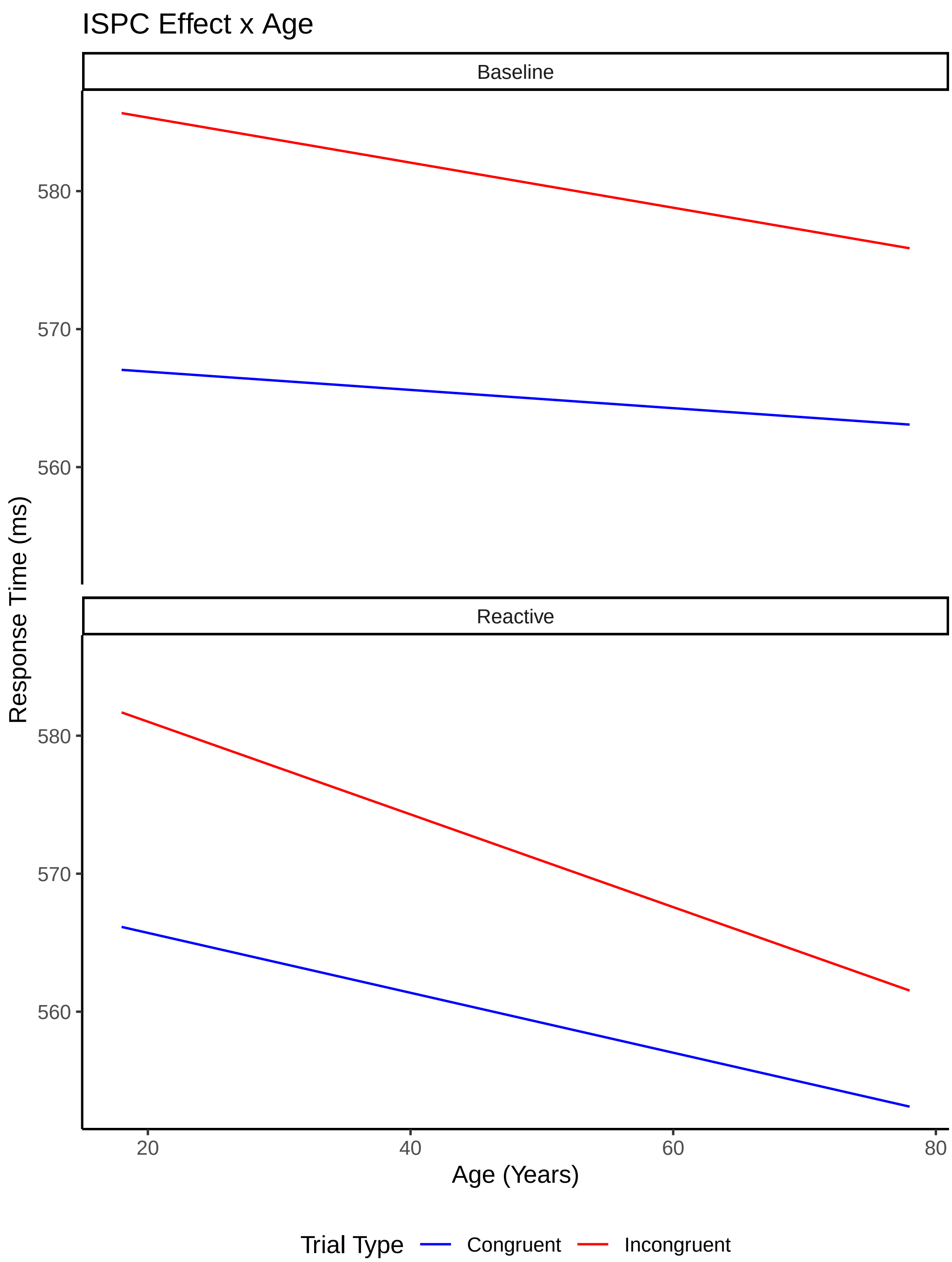
$$RT = mode\ x\ con\ x\ age + \left(1 + mode\ x\ con \mid ID\right)$$

Table 8: ISPC x Age Interaction for Inducer Items during Word Reading Blocks

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
Intercept	568.24	[544.47, 592.01]	46.85	325	< .001
ConIncongruent	20.36	[9.45, 31.27]	3.66	325	< .001
ModeReactive	1.81	[-14.90, 18.53]	0.21	349	.832
Age	-0.07	[-0.56, 0.43]	-0.26	325	.794
ConIncongruent × ModeReactive	-2.67	[-17.78, 12.44]	-0.35	915	.729
ConIncongruent × Age	-0.10	[-0.33, 0.13]	-0.84	327	.404
ModeReactive × Age	-0.15	[-0.50, 0.20]	-0.85	350	.397
ConIncongruent × ModeReactive × Age	-0.02	[-0.34, 0.29]	-0.13	920	.893

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ModeReactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the ISPC effect, is represented by the two-way interaction term ’ConIncongruent x ModeReactive’ and is not significant (β = -2.67 ms, CI = [-17.79, 12.44], t = -.35, p = .729). Its interaction with age is represented by the term ’ConIncongruent x ModeReactive x Age’ and is also not significant (β = -.02 ms, CI = [-.34, .29], t = -.13, p =.893).


ISPC Effect x Age
Baseline
Reactive
Response Time (ms)
580
570
560
580
570
560
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.10 Word Reading Congruency Cost

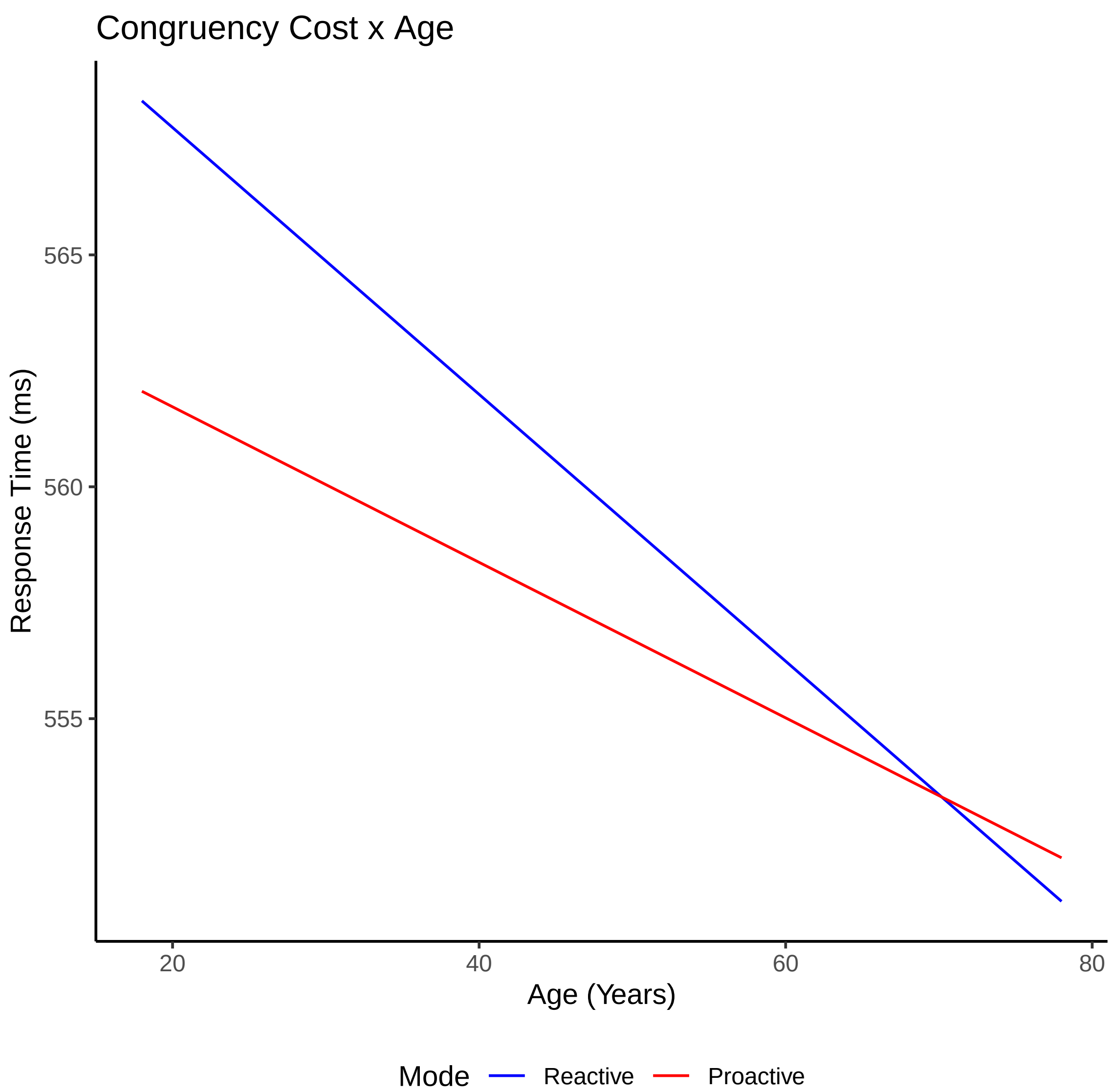
$$RT = mode\ x\ age + \left(1 + mode \mid ID\right)$$

Table 9: Congruency Cost x Age Interaction for Diagnostic Items

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
Intercept	573.50	[549.12, 597.87]	46.11	323	< .001
ModeProactive	-8.42	[-25.22, 8.37]	-0.98	322	.326
Age	-0.29	[-0.80, 0.22]	-1.11	323	.268
ModeProactive × Age	0.12	[-0.23, 0.47]	0.67	322	.503

Note. ModeProactive refers to the effect of Condition, with Reactive treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the congruency cost, is represented by the term 'ModeProactive' and is not significant (β = -8.42 ms, CI = [-25.22, 8.37], t = -.98, p = .326). Its interaction with age is represented by the two-way interaction term 'ModeProactive x Age' and is also not significant (β = .12 ms, CI = [-.23, .47], t = .67, p = .503).


Congruency Cost x Age
Response Time (ms)
565
560
555
20
40
60
80
Age (Years)
Mode
Reactive
Proactive

3.11 Word Reading Reactive Transfer Cost

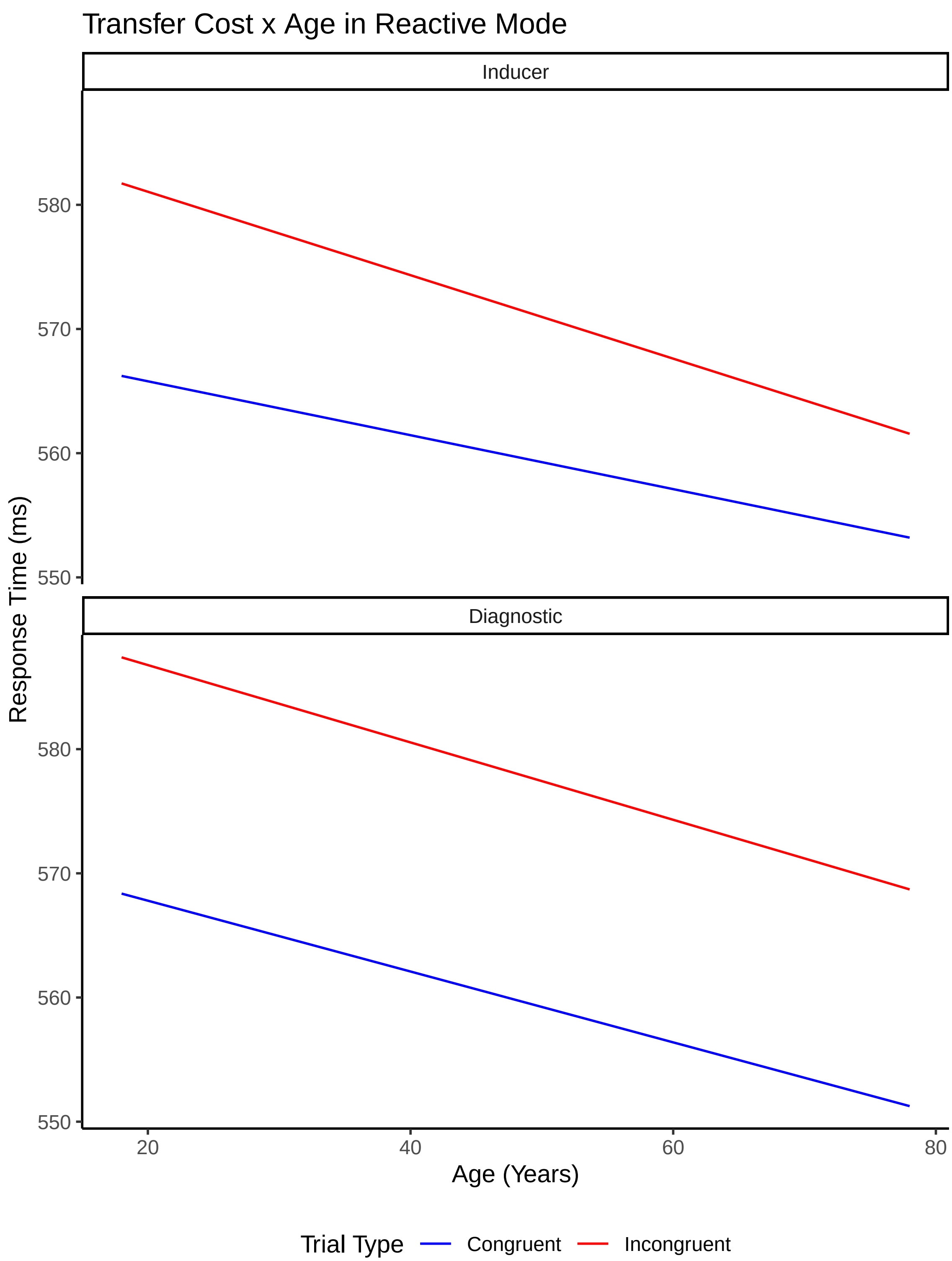
$$RT = con\ x\ item\ x\ age + \left(1 + con\ x\ item \mid ID\right)$$

Table 10: Reactive Transfer Cost x Age Interaction

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	570.13	[544.52, 595.74]	43.63	328	< .001
ItemDiagnostic	3.37	[-10.18, 16.92]	0.49	1882	.626
ConIncongruent	17.64	[5.25, 30.04]	2.79	907	.005
Age	-0.22	[-0.75, 0.32]	-0.80	328	.427
ItemDiagnostic × ConIncongruent	1.85	[-15.44, 19.14]	0.21	1561	.834
ItemDiagnostic × Age	-0.07	[-0.35, 0.21]	-0.47	1887	.637
ConIncongruent × Age	-0.12	[-0.38, 0.14]	-0.90	910	.368
ItemDiagnostic × ConIncongruent × Age	0.09	[-0.27, 0.45]	0.50	1564	.615

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the transfer cost in the reactive mode, is represented by the two-way interaction term 'ItemDiagnostic x ConIncongruent' and is not significant (β = 1.85 ms, CI = [-15.44, 19.14], t = .21, p = .834). Its interaction with age is represented by the three-way interaction term 'ItemDiagnostic x ConIncongruent x Age' and is also not significant (β = .09 ms, CI = [-.27, .45], t = .50, p = .615).



Transfer Cost x Age in Reactive Mode
Inducer
Diagnostic
Response Time (ms)
580
570
560
550
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.12 Word Reading Proactive Transfer Cost

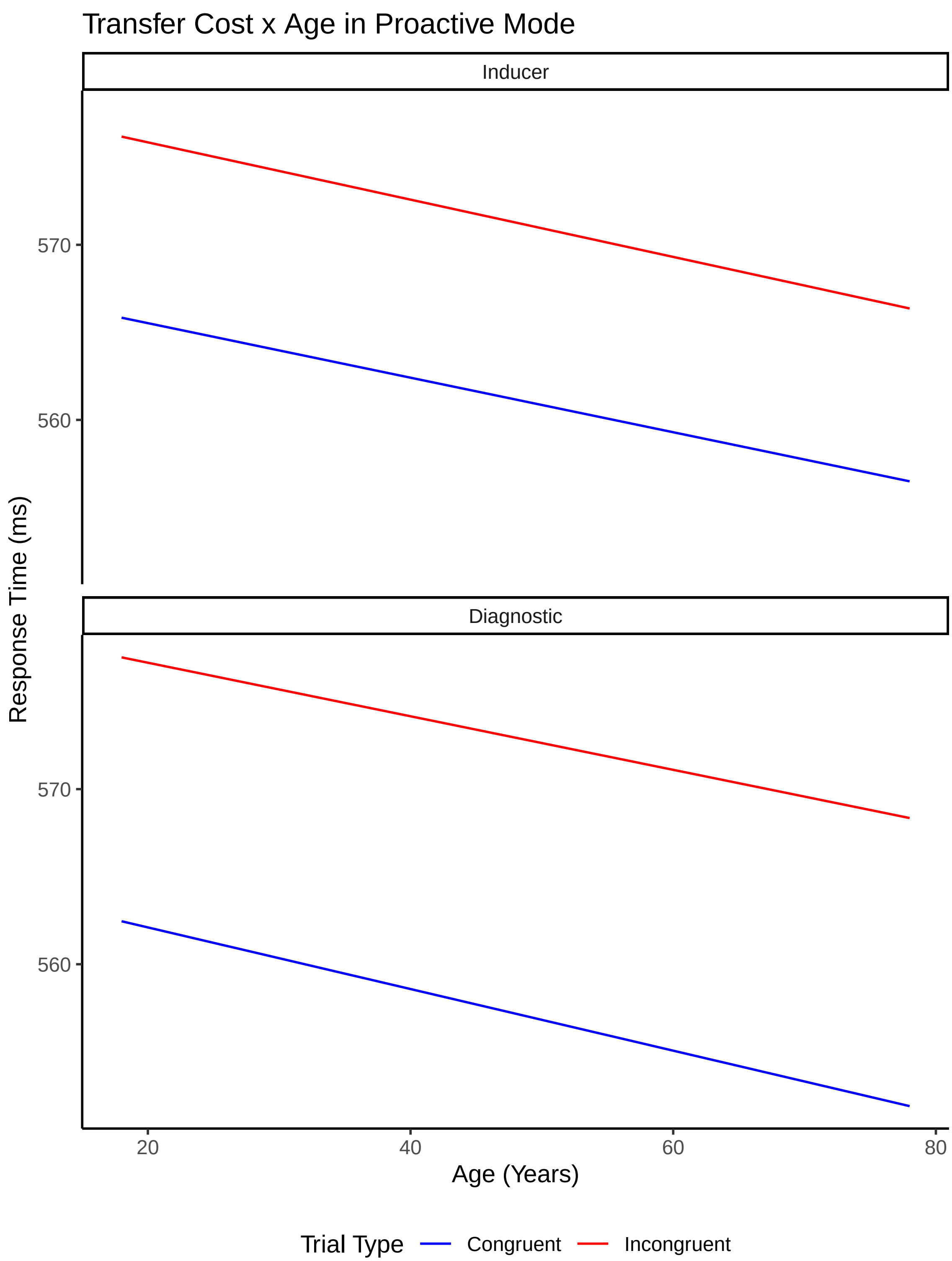
$$RT = con\ x\ item\ x\ age + (1 + con\ x\ item \mid ID)$$

Table 11: Proactive Transfer Cost x Age Interaction

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	568.64	[543.81, 593.47]	44.89	22308	< .001
ItemDiagnostic	-3.02	[-14.91, 8.87]	-0.50	22308	.619
ConIncongruent	10.48	[0.76, 20.20]	2.11	22308	.035
Age	-0.16	[-0.68, 0.36]	-0.59	325	.556
ItemDiagnostic × ConIncongruent	4.17	[-10.97, 19.31]	0.54	22308	.589
ItemDiagnostic × Age	-0.02	[-0.27, 0.23]	-0.16	22308	.873
ConIncongruent × Age	-0.01	[-0.21, 0.20]	-0.08	22308	.940
ItemDiagnostic × ConIncongruent × Age	0.03	[-0.28, 0.35]	0.19	22308	.848

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the transfer cost in the proactive mode, is represented by the two-way interaction term 'ItemDiagnostic x ConIncongruent' and is not significant (β = 4.17 ms, CI = [-10.97, 19.31], t = .54, p = .589). Its interaction with age is represented by the three-way interaction term 'ItemDiagnostic x ConIncongruent x Age' and is also not significant (β = .03 ms, CI = [-.28, .35], t = .19, p = .848).



Transfer Cost x Age in Proactive Mode
Inducer
Diagnostic
Response Time (ms)
570
560
570
560
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

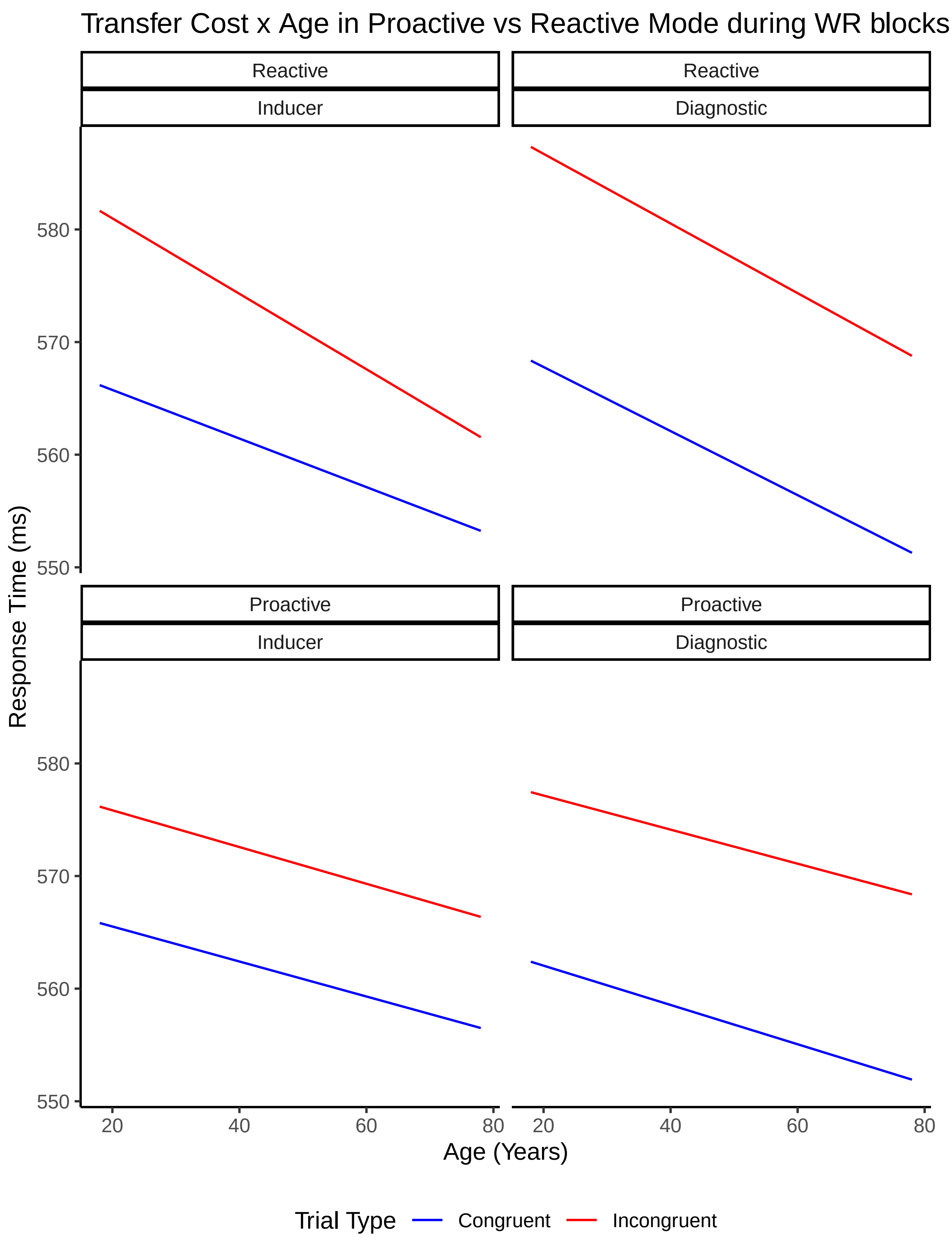
3.13 Word Reading Proactive - Reactive Transfer Cost

Table 12: Proactive - Reactive Transfer Cost x Age Interaction during Word Reading blocks

Term	$\hat{\beta}$	95% CI	*t*	*df*	*p*
Intercept	570.06	[544.44, 595.68]	43.61	39852	< .001
ItemDiagnostic	3.41	[-9.93, 16.75]	0.50	39852	.616
ConIncongruent	17.62	[5.12, 30.13]	2.76	39852	.006
ModeProactive	-1.43	[-19.91, 17.04]	-0.15	39852	.879
Age	-0.22	[-0.75, 0.32]	-0.79	325	.430
ItemDiagnostic × ConIncongruent	1.80	[-15.32, 18.92]	0.21	39852	.837
ItemDiagnostic × ModeProactive	-6.51	[-24.25, 11.23]	-0.72	39852	.472
ConIncongruent × ModeProactive	-7.15	[-22.70, 8.39]	-0.90	39852	.367
ItemDiagnostic × Age	-0.07	[-0.35, 0.21]	-0.48	39852	.629
ConIncongruent × Age	-0.12	[-0.38, 0.14]	-0.90	39852	.371
ModeProactive × Age	0.06	[-0.33, 0.45]	0.31	39852	.759
ItemDiagnostic × ConIncongruent × ModeProactive	2.37	[-20.50, 25.23]	0.20	39852	.839
ItemDiagnostic × ConIncongruent × Age	0.09	[-0.26, 0.45]	0.52	39852	.604
ItemDiagnostic × ModeProactive × Age	0.05	[-0.32, 0.42]	0.26	39852	.793
ConIncongruent × ModeProactive × Age	0.11	[-0.21, 0.44]	0.67	39852	.501
ItemDiagnostic × ConIncongruent × ModeProactive × Age	-0.06	[-0.54, 0.41]	-0.26	39852	.794

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ItemDiagnostic refers to the effect of Item Type, with Inducer treated as the reference value (intercept). ModeProactive refers to the Condition effect, with Reactive treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the difference in transfer cost between modes, is represented by the 3-way interaction term 'ItemDiagnostic x ConIncongruent x ModeProactive' and is not significant (β = 2.37 ms, CI = [-20.50, 25.23], t = .20, p = .839). Its interaction with age is represented by the four-way interaction term 'ItemDiagnostic x ConIncongruent x ModeProactive x Age' and is not significant either (β = -.06 ms, CI = [-.54, .41], t = -.26, p = .794).


Transfer Cost x Age in Proactive vs Reactive Mode during WR blocks
Reactive
Inducer
Reactive
Diagnostic
Proactive
Inducer
Proactive
Diagnostic
Response Time (ms)
550
560
570
580
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

3.14 Color Naming Cost for Proactive - Baseline Mode

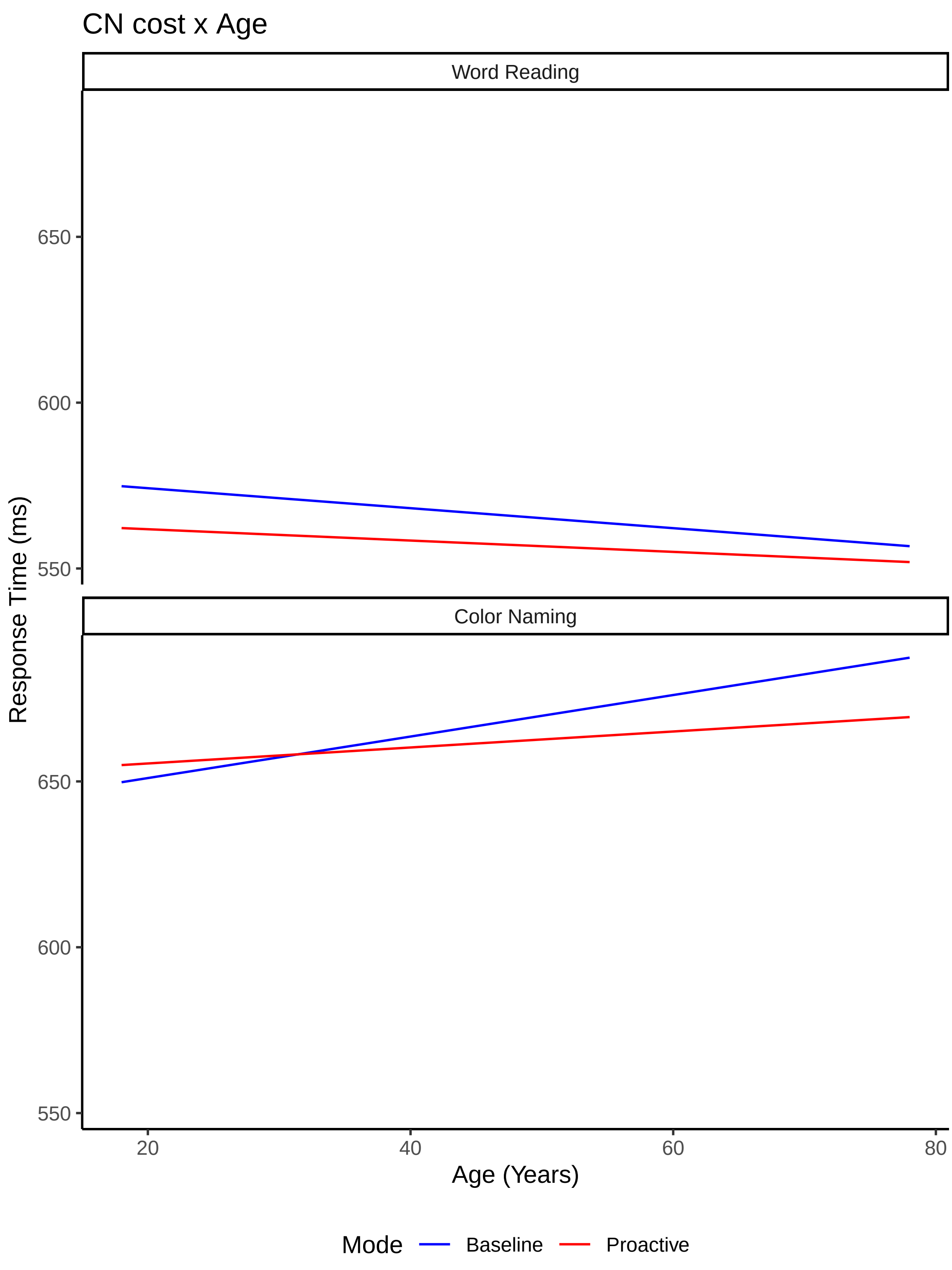
$$RT = mode\ x\ rule\ x\ age + \left(1 + mode\ x\ rule \mid ID\right)$$

Table 13: Color Naming Cost x Age Interaction for Diagnostic Items

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	580.23	[556.49, 603.98]	47.90	324	< .001
ModeProactive	-14.98	[-30.23, 0.26]	-1.93	322	.055
RuleColor Naming	58.26	[41.38, 75.15]	6.76	323	< .001
Age	-0.30	[-0.80, 0.19]	-1.19	324	.234
ModeProactive × RuleColor Naming	27.08	[9.73, 44.43]	3.06	318	.002
ModeProactive × Age	0.13	[-0.19, 0.45]	0.80	322	.422
RuleColor Naming × Age	0.93	[0.57, 1.28]	5.15	324	< .001
ModeProactive × RuleColor Naming × Age	-0.52	[-0.88, -0.15]	-2.79	318	.006

Note. ModeProactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). RuleColor Naming refers to the effect of Rule, with Word Reading treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the color naming cost, is represented by the two-way interaction term 'ModeProactive x RuleColor Naming' and is significant (β = 27.08 ms, CI = [9.73, 44.43], t = 3.06, p = .002). Its relationship with age is represented by the three-way interaction term 'ModeProactive x RuleColor Naming x Age' and is also significant (β = -.52 ms, CI = [-.88, -.15], t = -2.79, p = .006). The age in which the effect goes to zero is 52.1 years old.



CN cost x Age
Word Reading
Color Naming
Response Time (ms)
650
600
550
650
600
550
20
40
60
80
Age (Years)
Mode
Baseline
Proactive

3.15 Color Naming Cost for Proactive - Reactive Mode

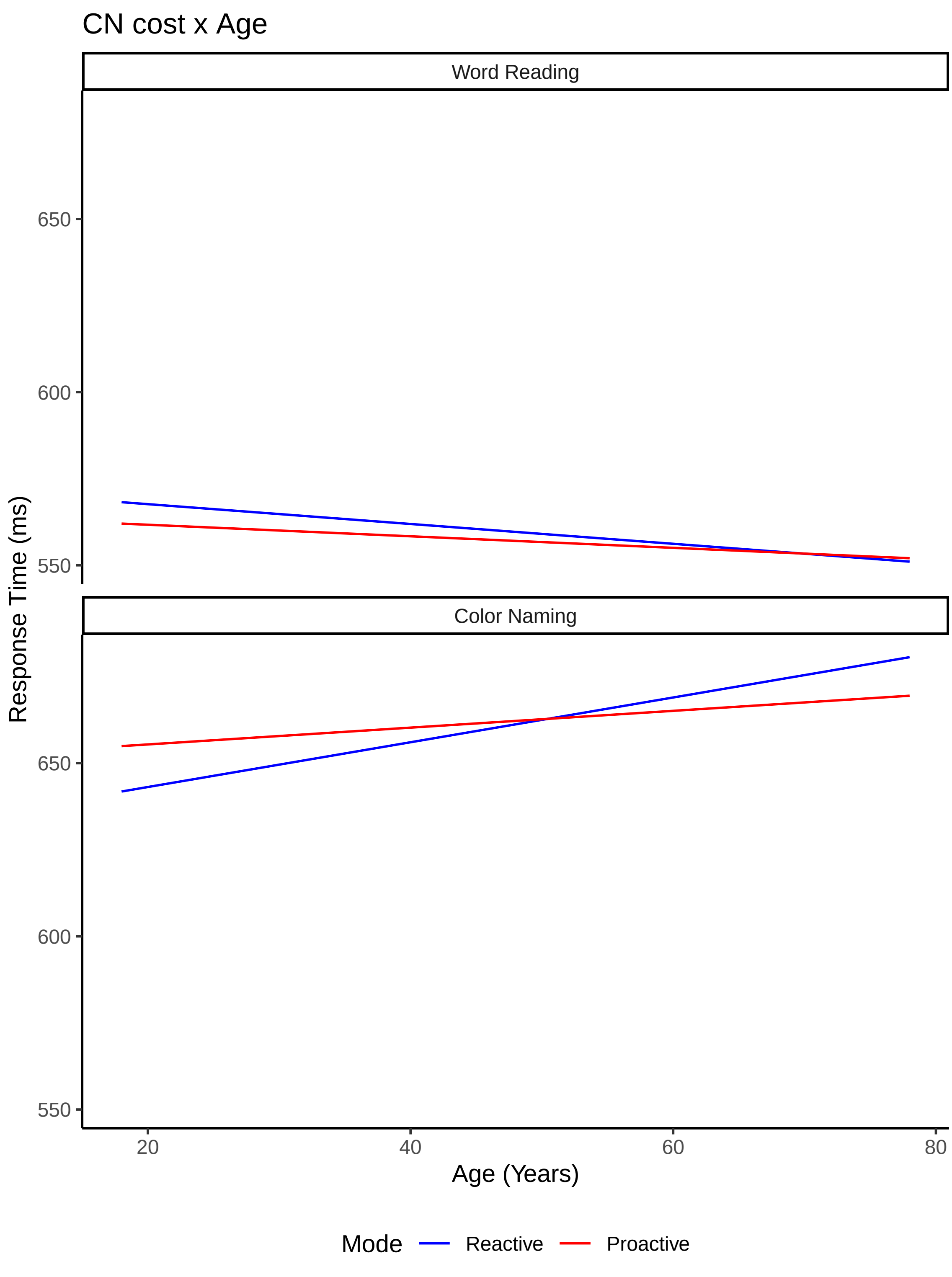
$$RT = mode\ x\ rule\ x\ age + \left(1 + mode\ x\ rule \mid ID\right)$$

Table 14: Color Naming Cost x Age Interaction for Diagnostic Items

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	573.38	[549.06, 597.70]	46.20	323	< .001
ModeProactive	-8.34	[-25.11, 8.44]	-0.97	322	.331
RuleColor Naming	56.81	[39.21, 74.41]	6.33	323	< .001
Age	-0.29	[-0.79, 0.22]	-1.11	323	.270
ModeProactive × RuleColor Naming	28.71	[10.79, 46.64]	3.14	320	.002
ModeProactive × Age	0.12	[-0.23, 0.47]	0.67	322	.504
RuleColor Naming × Age	0.93	[0.57, 1.30]	4.98	323	< .001
ModeProactive × RuleColor Naming × Age	-0.52	[-0.90, -0.15]	-2.74	320	.006

Note. ModeProactive refers to the effect of Condition, with Reactive treated as the reference value (intercept). RuleColor Naming refers to the effect of Rule, with Word Reading treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept).

The key effect, the color naming cost, is represented by the two-way interaction term 'ModeProactive x RuleColor Naming' and is significant (β = 28.71 ms, CI = [10.79, 46.64], t = 3.14, p = .002). Its relationship with age is represented by the three-way interaction term 'ModeProactive x RuleColor Naming x Age' and is also significant (β = -.52 ms, CI = [-.90, -.15], t = -2.74, p = .006). The age in which the effect goes to zero is 55.2 years old.


CN cost x Age
Word Reading
Color Naming
650
600
550
650
600
550
Response Time (ms)
20
40
60
80
Age (Years)
Mode
Reactive
Proactive

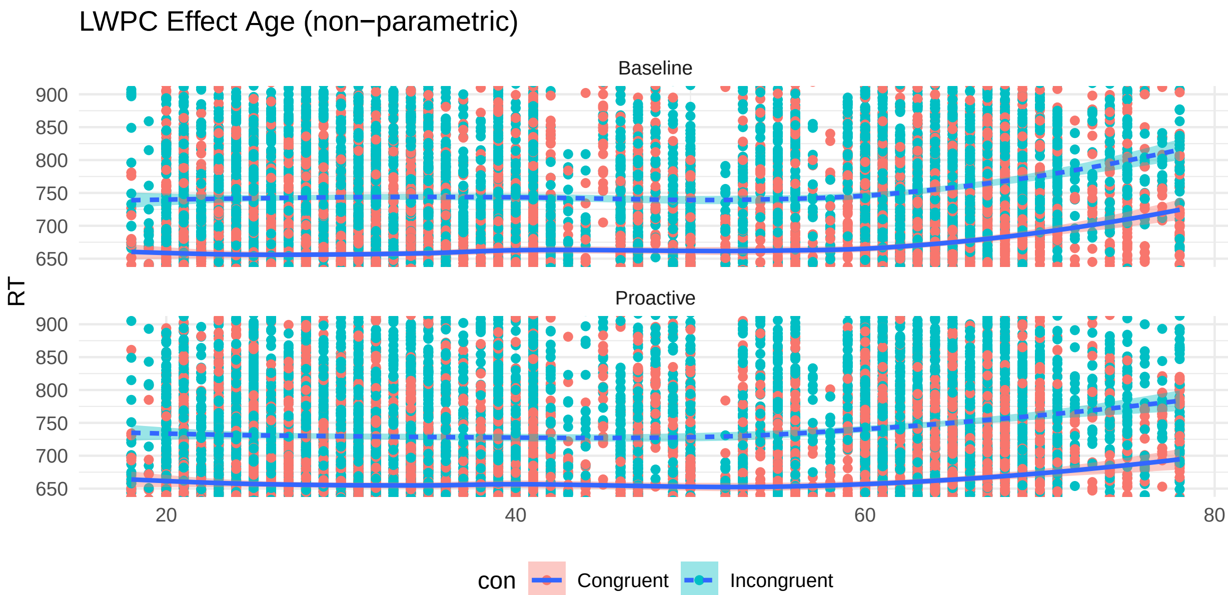
4 Nonlinear Mixed-Effect Model Results

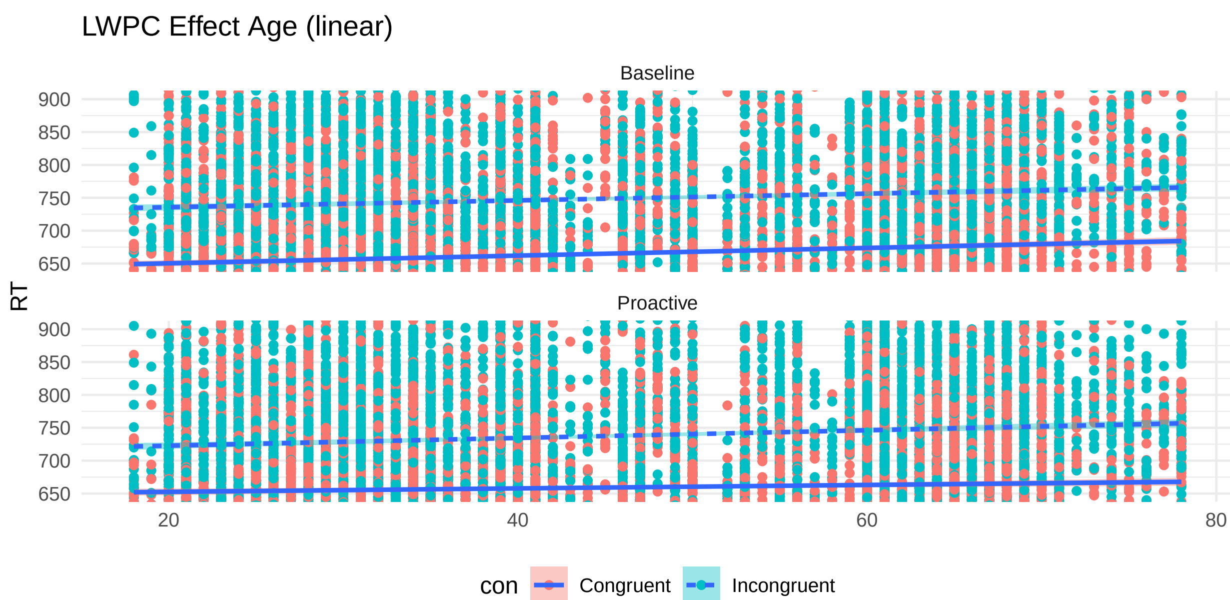
For these set of mixed-effect model analyses, the primary goal was to consider a non-linear effect of age on the proactive/reactive control indicators for the CN blocks (i.e., LWPC, ISPC, congruency cost, transfer cost). We first explored the results of mapping loess functions onto subsets of scatterplot data related to each proactive/reactive control indicator within CN blocks (i.e., LWPC, ISPC, congruency cost, transfer cost). In all cases, the loess fits deviated significantly from an assumed linear relationship between age and RT. Considering this initial finding, we next compared the relative predictive accuracy of parametric regression models that had different polynomial terms for age (i.e., linear, quadratic, cubic) and random effect structures (i.e., without random effects, random intercepts, random effects for each proactive/reactive control indicator). Since we previously established the improved model fits obtained by adopting a maximal random effect structure for our models, we feel these models are the most relevant for determining whether there are significant benefits for including a quadratic/cubic versus linear 'age' term.

Interestingly, model comparisons between polynomial terms across proactive/reactive control indicators overall indicated that the more complex assumption of a nonlinear relationship between age and RT did not significantly improve model performance for our data. Our interpretation of this finding is that it is related to the more accurate modeling of subject-level dependencies within this dataset, as well as the shrinkage of outlying subject-level estimates (which might spuriously promote some nonlinear age patterns). The only effect in which there was a universal benefit of adopting a nonlinear (cubic) age term, was for the ISPC effect; however, the cubic pattern comes with a cost of reduced interpretability, both theoretically and quantitatively. Since our previous qualitative conclusions for this indicator also do not change, we conclude that the original choice of linear age effects for all our measures is sufficient to capture meaningful patterns within the current dataset.

4.1 Color Naming LWPC Effect

4.1.1 Scatterplots LWPC Effect





The non-parametric loess regression output seems to suggest a nonlinear relationship between age and RT across conditions and modes.

4.1.2 LWPC models with max random effects

Table 1: Model Comparison (Linear vs Quadratic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	341657	341814	-170809	341,619.11	NA	NA	NA
23	341661	341851	-170807	341,615.88	3.23	4.00	0.52

Note. The difference in AIC between the linear model (341657) and the quadratic model (341661) is not significant $\chi^2(4, 327) = 3.23$, p = 0.52.

Table 2: Model Comparison (Linear vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	341657	341814	-170809	341,619.11	NA	NA	NA
27	341663	341886	-170804	341,609.17	9.94	8.00	0.27

Note. The difference in AIC between the linear model (341657) and the cubic model (341663) is not significant $\chi^2(8, 327) = 9.94$, p = 0.27.

Table 3: Model Comparison (Quadratic vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
23	341661	341851	-170807	341,615.88	NA	NA	NA
27	341663	341886	-170804	341,609.17	6.71	4.00	0.15

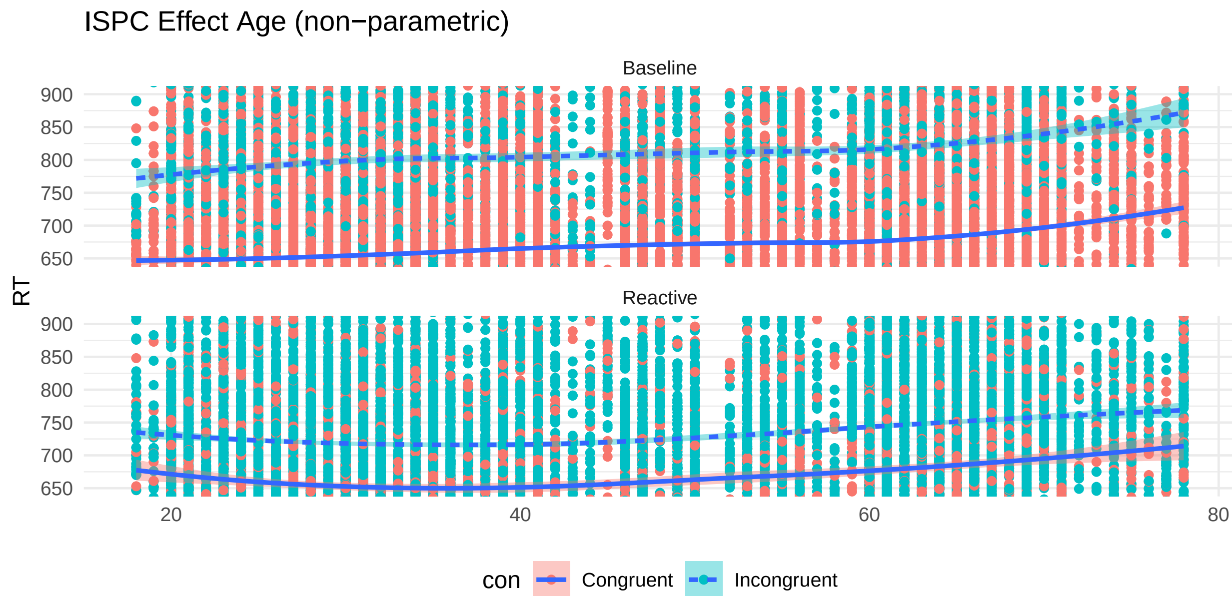
Note. The difference in AIC between the quadratic model (341661) and the cubic model (341663) is not significant $\chi^2(4, 327) = 6.71$, p = 0.15.

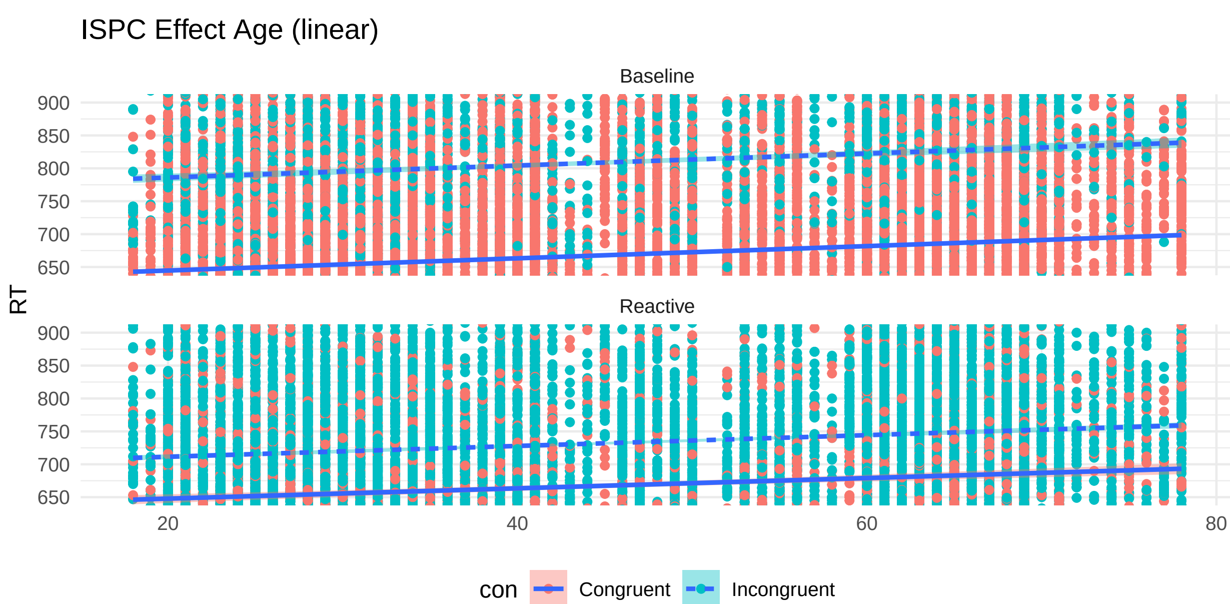
Comparison of the maximal random effect models shows the linear relationship between age and RT provides the best model fit.

Conclusion: A linear mixed-effect model with maximal effect structure seems to best explain the underlying characteristics of the data. Although the loess regression indicated there is some non-linear relationship between age and RT, this dynamic becomes significantly less pronounced with more complex mixed effect models, possibly due to the accurate modeling of the subject-level dependencies within the data as well as the shrinkage of outlying estimates. We see robust qualitative conclusions for a LWPC effect that diminishes with increasing age.

4.2 Color Naming ISPC Effect

4.2.1 Scatterplots ISPC Effect





The non-parametric loess regression output seems to suggest a nonlinear relationship between age and RT across conditions and modes.

4.2.2 ISPC models with maximal random effects

Table 4: Model Comparison (Linear vs Quadratic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	549137	549303	-274549	549,099.38	NA	NA	NA
23	549137	549338	-274545	549,091.84	7.53	4.00	0.11

Note. The difference in AIC between the linear model (549137) and the quadratic model (549137) is not significant $\chi^2(4, 327) = 7.53$, p = 0.11.

Table 5: Model Comparison (Linear vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	549137	549303	-274549	549,099.38	NA	NA	NA
27	549135	549371	-274540	549,081.61	17.77	8.00	0.02

Note. The difference in AIC between the linear model (549137) and the cubic model (549135) is significant $\chi^2(8, 327) = 17.77$, p = 0.02.

Table 6: Model Comparison (Quadratic vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
23	549137	549338	-274545	549,091.84	NA	NA	NA
27	549135	549371	-274540	549,081.61	10.23	4.00	0.04

Note. The difference in AIC between the quadratic model (549137) and the cubic model (549135) is significant $\chi^2(4, 327) = 10.23$, p = 0.04.

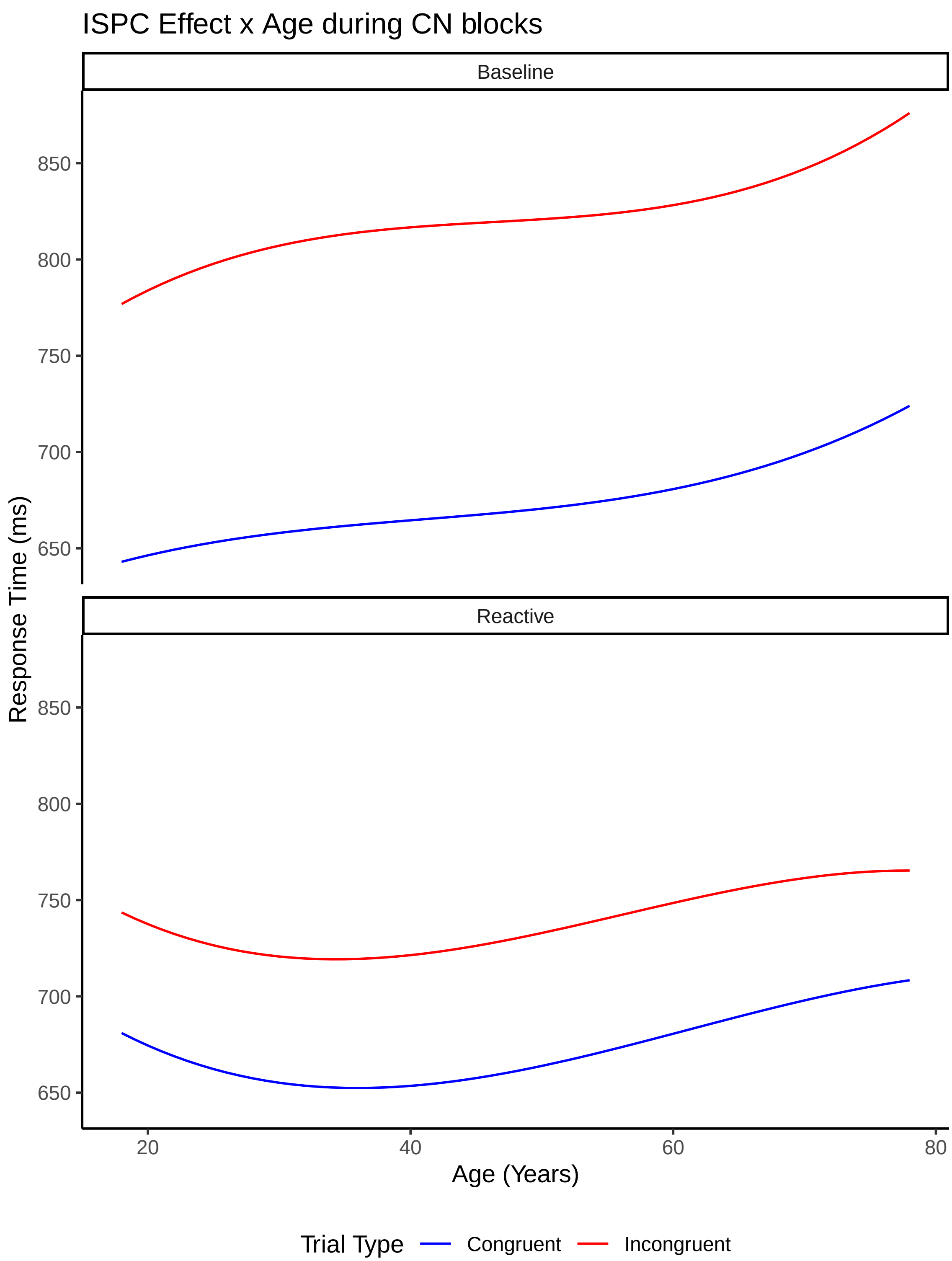
Comparison of maximal random effect models show a nonlinear/cubic relationship between age and RT provides the best model fit.

Table 7: ISPC x Age Interaction for Inducer Items during Color Naming Blocks

Term	$\hat{\beta}$	95% CI	t	df	p
Intercept	670.32	[662.28, 678.37]	163.29	323	< .001
ConIncongruent	147.98	[142.77, 153.20]	55.64	313	< .001
ModeReactive	-0.72	[-6.51, 5.07]	-0.24	317	.807
Polyage, 31	3,436.08	[1,731.97, 5,140.19]	3.95	323	< .001
Polyage, 32	547.44	[-1,151.86, 2,246.73]	0.63	324	.528
Polyage, 33	570.77	[-1,118.77, 2,260.30]	0.66	324	.508
ConIncongruent × ModeReactive	-81.94	[-88.08, -75.81]	-26.18	316	< .001
ConIncongruent × Polyage, 31	143.54	[-970.47, 1,257.55]	0.25	323	.801
ConIncongruent × Polyage, 32	-513.74	[-1,634.96, 607.47]	-0.90	331	.370
ConIncongruent × Polyage, 33	476.34	[-657.79, 1,610.47]	0.82	349	.411
ModeReactive × Polyage, 31	-642.15	[-1,869.67, 585.37]	-1.03	318	.306
ModeReactive × Polyage, 32	1,281.98	[57.77, 2,506.19]	2.05	319	.041
ModeReactive × Polyage, 33	-1,279.22	[-2,496.02, -62.42]	-2.06	319	.040
ConIncongruent × ModeReactive × Polyage, 31	-90.75	[-1,399.21, 1,217.72]	-0.14	325	.892
ConIncongruent × ModeReactive × Polyage, 32	99.74	[-1,213.87, 1,413.34]	0.15	332	.882
ConIncongruent × ModeReactive × Polyage, 33	-604.98	[-1,926.80, 716.83]	-0.90	346	.370

Note. ConIncongruent refers to the Trial Type effect, with Congruent treated as the reference value (intercept). ModeReactive refers to the effect of Condition, with Baseline treated as the reference value (intercept). Age refers to the continuous effect of age with 0 years treated as the reference value (intercept). There are 3 components: linear, quadratic, cubic

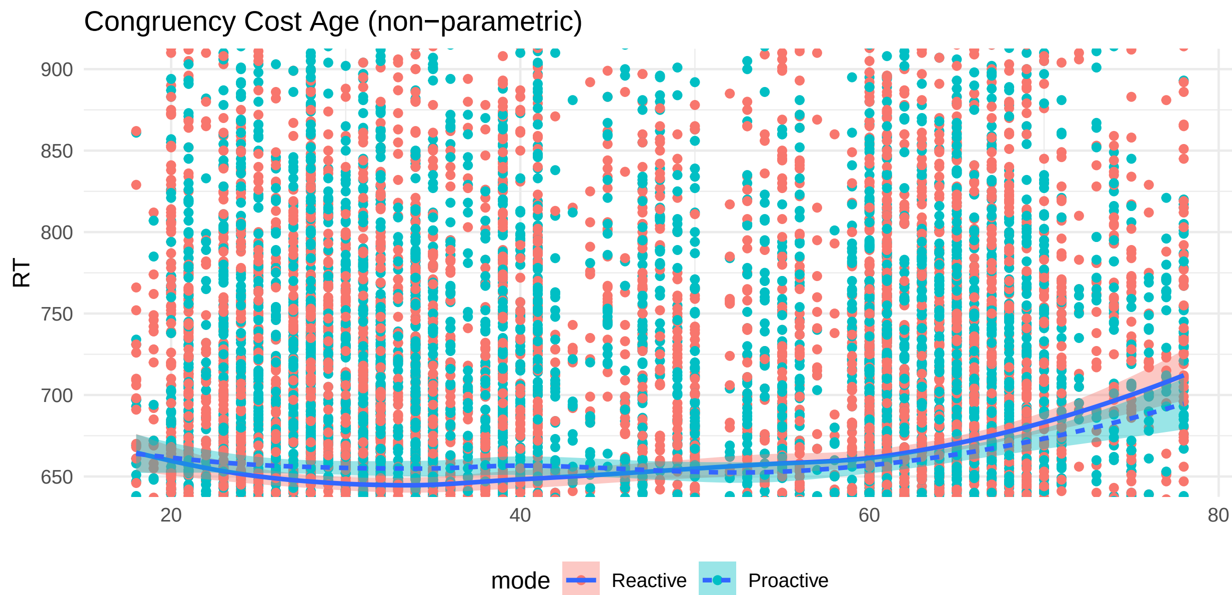
For the cubic model, the coefficients collectively indicate there seems to be some influence of the quadratic and cubic terms on the results, but there is no 3-way interaction across the age components. The qualitative finding indicates that the ISPC effect at age 0 is significant ($p < .001$), and this effect does not diminish with age ($p > .05$).

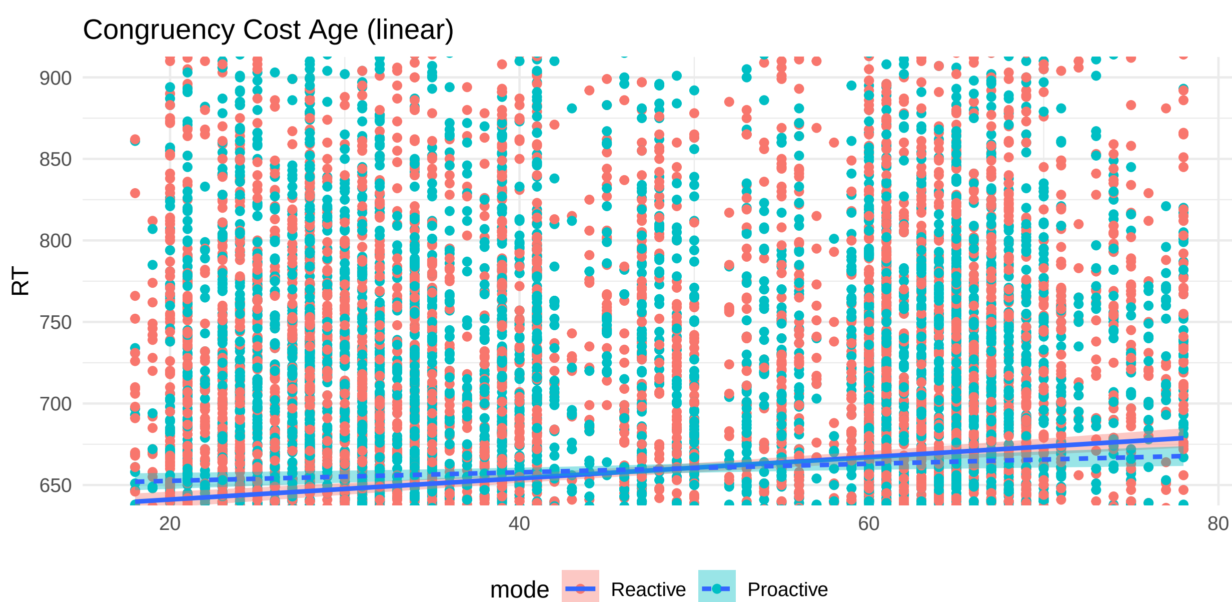

ISPC Effect x Age during CN blocks
Baseline
Reactive
Response Time (ms)
650
700
750
800
850
20
40
60
80
Age (Years)
Trial Type
Congruent
Incongruent

Conclusion: A cubic mixed-effect model with maximal effect structure seems to best explain the underlying characteristics of the data. The loess regression indicated there is some nonlinear relationship between age and RT; while this dynamic becomes less pronounced with more complex mixed-effect models, possibly due to the accurate modeling of the subject-level dependencies within the data as well as the shrinkage of outlying estimates, the cubic model still remains as the best-fitting model. However, the qualitative conclusions remain the same across modeling approach: the ISPC effect does not diminish with increasing age. Considering the more straightforward interpretation of the linear coefficients, it may still be worthwhile to use a linear model to explain the relationship between age and the ISPC effect.

4.3 Color Naming Congruency Cost

4.3.1 Scatterplots Congruency Cost





The non-parametric loess regression output seems to suggest a nonlinear relationship between age and RT across conditions and modes.

4.3.2 Congruency cost models with maximal random effects

Table 8: Model Comparison (Linear vs Quadratic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
8	178273	178333	-89128	178,257.16	NA	NA	NA
10	178274	178350	-89127	178,254.08	3.08	2.00	0.21

Note. The difference in AIC between the linear model (178273) and the quadratic model (178274) is not significant $\chi^2(2, 327) = 3.08$, p = 0.21.

Table 9: Model Comparison (Linear vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
8	178273	178333	-89128	178,257.16	NA	NA	NA
12	178278	178369	-89127	178,254.06	3.10	4.00	0.54

Note. The difference in AIC between the linear model (178273) and the cubic model (178278) is not significant $\chi^2(4, 327) = 3.1$, p = 0.54.

Table 10: Model Comparison (Quadratic vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
10	178274	178350	-89127	178,254.08	NA	NA	NA
12	178278	178369	-89127	178,254.06	0.02	2.00	0.99

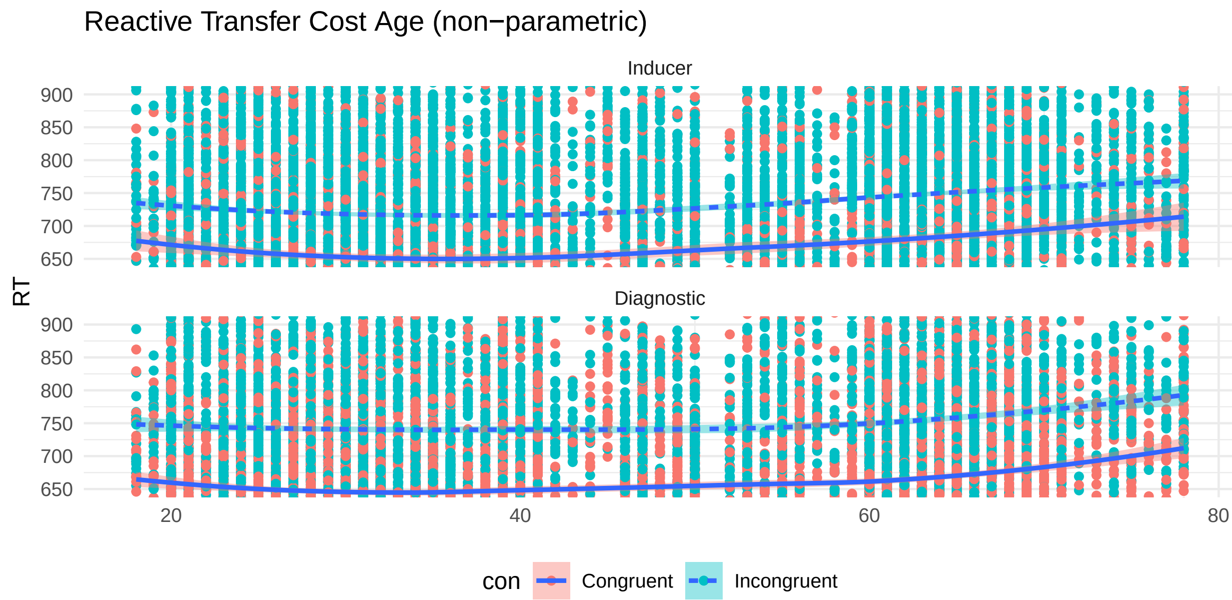
Note. The difference in AIC between the quadratic model (178274) and the cubic model (178278) is not significant $\chi^2(2, 327) = 0.02$, p = 0.99.

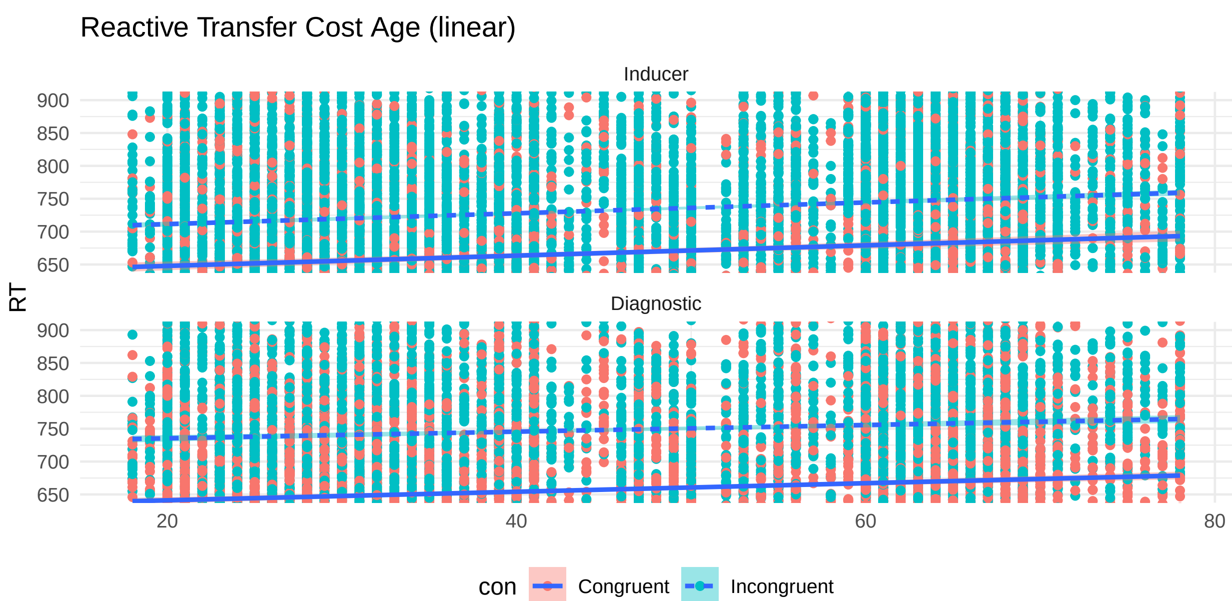
Comparison of the maximal random effects models show the linear relationship between age and RT provides the best model fit.

Conclusion: A linear mixed-effect model with maximal effect structure seems to best explain the underlying characteristics of the data. Although the loess regression indicated there is some non-linear relationship between age and RT, this dynamic becomes significantly less pronounced with more complex mixed effect models, possibly due to the accurate modeling of the subject-level dependencies within the data as well as the shrinkage of outlying estimates. We see robust qualitative conclusions for the congruency cost that diminishes with increasing age.

4.4 Color Naming Reactive Transfer Cost

4.4.1 Scatterplots Reactive Transfer Cost





The non-parametric loess regression output seems to suggest a nonlinear relationship between age and RT across conditions and modes.

4.4.2 Reactive transfer cost models with maximal random effects

Table 11: Model Comparison (Linear vs Quadratic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	403016	403175	-201489	402,978.04	NA	NA	NA
23	403020	403213	-201487	402,974.48	3.55	4.00	0.47

Note. The difference in AIC between the linear model (403016) and the quadratic model (403020) is not significant $\chi^2(4, 327) = 3.55$, p = 0.47.

Table 12: Model Comparison (Linear vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	403016	403175	-201489	402,978.04	NA	NA	NA
27	403021	403248	-201483	402,967.17	10.86	8.00	0.21

Note. The difference in AIC between the linear model (403016) and the cubic model (403021) is not significant $\chi^2(8, 327) = 10.86$, p = 0.21.

Table 13: Model Comparison (Quadratic vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
23	403020	403213	-201487	402,974.48	NA	NA	NA
27	403021	403248	-201483	402,967.17	7.31	4.00	0.12

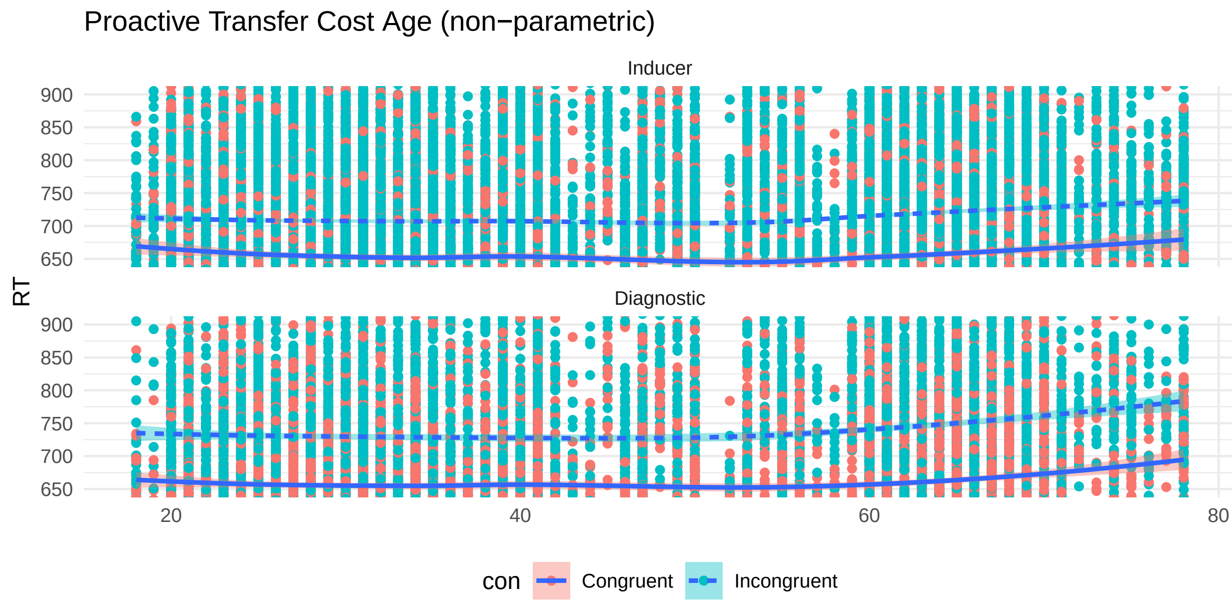
Note. The difference in AIC between the quadratic model (403020) and the cubic model (403021) is not significant $\chi^2(4, 327) = 7.31$, p = 0.12.

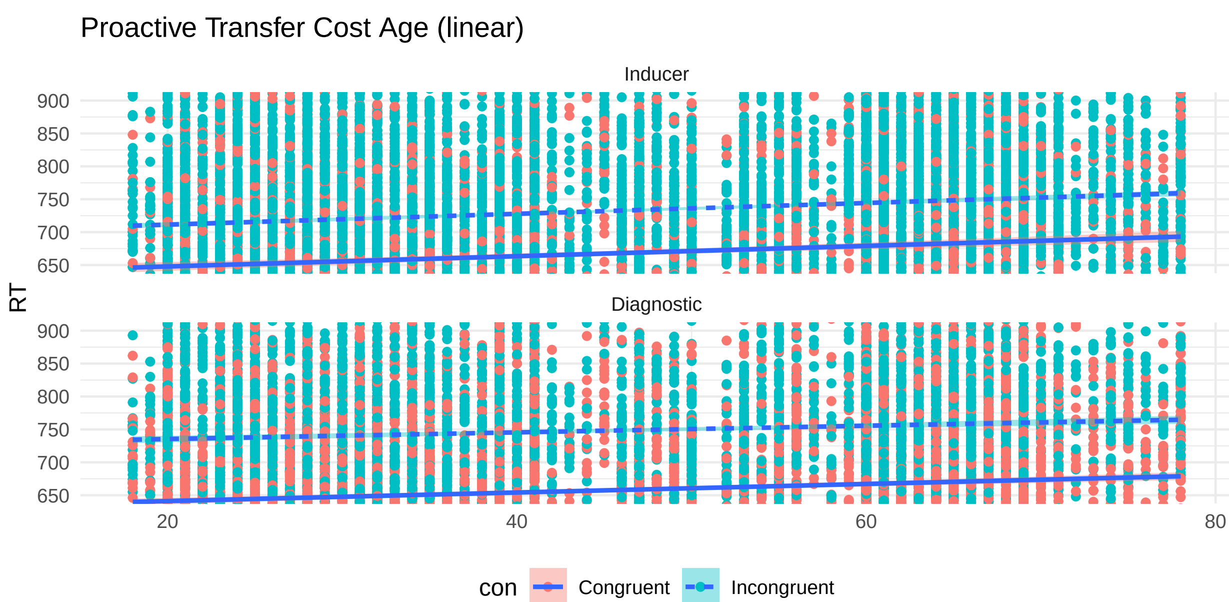
Comparison of maximal random effects models show a linear relationship between age and RT provides the best model fit.

Conclusion: A linear mixed-effect model with maximal effect structure seems to best explain the underlying characteristics of the data. Although the loess regression indicated there is some non-linear relationship between age and RT, this dynamic becomes significantly less pronounced with more complex mixed effect models, possibly due to the accurate modeling of the subject-level dependencies within the data as well as the shrinkage of outlying estimates. We see robust qualitative conclusions for the reactive transfer cost that does not diminish with increasing age.

4.5 Color Naming Proactive Transfer Cost

4.5.1 Scatterplots Proactive Transfer Cost





The non-parametric loess regression output seems to suggest a nonlinear relationship between age and RT across conditions and modes.

4.5.2 Proactive transfer cost models with maximal random effects

Table 14: Model Comparison (Linear vs Quadratic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	523924	524089	-261943	523,886.38	NA	NA	NA
23	523928	524127	-261941	523,882.19	4.18	4.00	0.38

Note. The difference in AIC between the linear model (523924) and the quadratic model (523928) is not significant $\chi^2(4, 327) = 4.18$, p = 0.38.

Table 15: Model Comparison (Linear vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
19	523924	524089	-261943	523,886.38	NA	NA	NA
27	523933	524167	-261939	523,879.42	6.96	8.00	0.54

Note. The difference in AIC between the linear model (523924) and the cubic model (523933) is not significant $\chi^2(8, 327) = 6.96$, p = 0.54.

Table 16: Model Comparison (Quadratic vs Cubic)

npar	AIC	BIC	logLik	deviance	Chisq	Df	Pr(>Chisq)
23	523928	524127	-261941	523,882.19	NA	NA	NA
27	523933	524167	-261939	523,879.42	2.78	4.00	0.60

Note. The difference in AIC between the quadratic model (523928) and the cubic model (523933) is not significant $\chi^2(4, 327) = 2.78$, p = 0.6.

Comparison of max random effects models show a linear relationship between age and RT provides the best model fit.

Conclusion: A linear mixed-effect model with maximal effect structure seems to best explain the underlying characteristics of the data. Although the loess regression indicated there is some non-linear relationship between age and RT, this dynamic becomes significantly less pronounced with more complex mixed effect models, possibly due to the accurate modeling of the subject-level dependencies within the data as well as the shrinkage of outlying estimates. We see robust qualitative conclusions for a proactive transfer cost that does not diminish with increasing age.

5 ANOVA Results for Cross-Effect Interactions

We aim to formally test the double dissociation between transfer cost and congruency cost across proactive and reactive control. We first computed each participant's transfer cost and congruency cost separately for proactive and reactive conditions. Transfer cost was calculated as the difference in Stroop effects between diagnostic and inducer items. Congruency cost was calculated separately for proactive and reactive conditions as the difference in reaction times for diagnostic congruent items between the respective control condition (proactive or reactive) and baseline. A repeated-measures ANOVA was conducted with effect type (transfer vs. congruency cost) and control type (proactive vs. reactive) as within-subject factors, and age group (younger, middle-aged, older) as a between-subjects factor. This analysis allowed us to determine whether the crossover interaction—where congruency cost is larger in proactive control and transfer cost is larger in reactive control—was present across age groups.

Table 1: Cross-Task Interactions between Transfer and Congruency Costs across Age Groups

Effect	DFn	DFd	SSn	SSd	F	p	p<.05	ges
(Intercept)	1	324	119,060	647,317	59.59	0.000	*	0.05
agecat	2	324	6,132	647,317	1.53	0.217		0.00
effect	1	324	325,465	900,865	117.06	0.000	*	0.12
mode	1	324	852	328,515	0.84	0.360		0.00
agecat:effect	2	324	2,653	900,865	0.48	0.621		0.00
agecat:mode	2	324	267	328,515	0.13	0.877		0.00
effect:mode	1	324	5,108	548,694	3.02	0.083		0.00
agecat:effect:mode	2	324	12,848	548,694	3.79	0.024	*	0.01

Note. To assess cross-task interactions, we compared reactive and proactive color naming blocks with a 3 (Age Groups: Younger, Middle-Aged, Older) x 2 (Condition: Reactive, Proactive) x 2 (Effect: Transfer Cost, Congruency Cost) mixed-effect ANOVA design.

Table 2: Cross-Task Interactions between Transfer and Congruency Costs (YA)

Effect	DFn	DFd	SSn	SSd	F	p	p<.05	ges
(Intercept)	1	113	71,821	283,896	28.59	0.000	*	0.07
effect	1	113	86,795	334,919	29.28	0.000	*	0.09
mode	1	113	106	99,884	0.12	0.730		0.00
effect:mode	1	113	14,075	205,845	7.73	0.006	*	0.01

Note. To assess cross-task interactions, we compared reactive and proactive color naming blocks with a 2 (Condition: Reactive, Proactive) x 2 (Effect: Transfer Cost, Congruency Cost) mixed-effect ANOVA design for younger adults.

Table 3: Cross-Task Interactions between Transfer and Congruency Costs (MA)

Effect	DFn	DFd	SSn	SSd	F	p	p<.05	ges
(Intercept)	1	102	28,837	170,323	17.27	0.000	*	0.04
effect	1	102	115,718	260,135	45.37	0.000	*	0.15
mode	1	102	874	101,121	0.88	0.350		0.00
effect:mode	1	102	2,321	149,809	1.58	0.212		0.00

Note. To assess cross-task interactions, we compared reactive and proactive color naming blocks with a 2 (Condition: Reactive, Proactive) x 2 (Trial Type: Congruent, Incongruent) mixed-effect ANOVA design for middle-aged adults.

Table 4: Cross-Task Interactions between Transfer and Congruency Costs (OA)

Effect	DFn	DFd	SSn	SSd	F	p	p<.05	ges
(Intercept)	1	109	26,299	193,097	14.85	0.000	*	0.03
effect	1	109	124,319	305,811	44.31	0.000	*	0.13
mode	1	109	103	127,510	0.09	0.767		0.00
effect:mode	1	109	1,753	193,040	0.99	0.322		0.00

Note. To assess cross-task interactions, we compared baseline and proactive color naming blocks with a 2 (Condition: Reactive, Proactive) x 2 (Trial Type: Congruent, Incongruent) mixed-effect ANOVA design for older adults.

6 Mixed-Effect Model without Participant Exclusion Results

In our analyses, we excluded participants with a high degree of erroneous responses (i.e., larger than 20 percent), as pre-registered. This was necessary to ensure that low performance or inaccurate speech recognition did not introduce noise into the data, potentially confounding our measures of proactive and reactive control. However, some reviewers raised concerns about whether these exclusions may have affected patterns of differentially affected age-related changes in cognitive control, given the varying numbers of excluded participants across age groups (25 younger adults, 24 middle-aged adults, and 11 older adults). To address reviewer concerns regarding potential biases introduced by our exclusion criteria, we conducted supplementary analyses in which no participants were excluded based on accuracy or missing data. These analyses aimed to determine whether the observed age-related decline in proactive control and preserved reactive control were influenced by participant exclusions. Using linear mixed-effects models to account for missing data, we found that the critical pattern of results remained unchanged: proactive control declined with age, while reactive control remained intact. These findings confirm that our key conclusions are not driven by exclusion criteria and support the robustness of our results. Below, we report the full statistical details of these supplementary analyses.

6.1 Color Naming LWPC Effect

6.1.1 Color Naming LWPC x AgeCat

$$RT = Condition\ x\ TrialType\ x\ Age + (1 + Condition\ x\ TrialType \mid ID)$$

Table 1: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	12,261,996	12,261,996	1	382.17	1,387.84	0.000
Condition	207,575	207,575	1	365.51	23.49	0.000
Age	15,080	7,540	2	382.08	0.85	0.427
Trial Type:Condition	37,195	37,195	1	356.08	4.21	0.041
Trial Type:Age	14,140	7,070	2	382.26	0.80	0.450
Condition:Age	19,742	9,871	2	365.61	1.12	0.328
Trial Type:Condition:Age	113,747	56,873	2	356.21	6.44	0.002

Note. To assess proactive control, we compared baseline and proactive color naming blocks with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on diagnostic items. Age was a between-subject variable.

6.1.2 Color Naming LWPC within Age Groups

Table 2: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks with Younger Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	5,683,811	5,683,811	1	135.58	537.18	0.000
Condition	84,425	84,425	1	11,134.44	7.98	0.005
Trial Type:Condition	108,403	108,403	1	11,162.42	10.25	0.001

Note. To assess proactive control, we compared baseline and proactive color naming blocks with a 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on diagnostic items for younger adults.

Table 3: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks with Middle-Aged Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	3,910,642	3,910,642	1	126.96	476.76	0.000
Condition	386,606	386,606	1	10,349.45	47.13	0.000
Trial Type:Condition	40,946	40,946	1	10,381.26	4.99	0.025

Note. We also compared baseline and proactive color naming blocks with a 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on diagnostic items for middle-aged adults.

Table 4: LWPC x Age Interaction for Diagnostic Items during Color Naming Blocks with Older Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	3,274,769	3,274,769	1	119.32	398.46	0.000
Condition	229,270	229,270	1	10,060.40	27.90	0.000
Trial Type:Condition	21,512	21,512	1	10,081.61	2.62	0.106

Note. We also compared baseline and proactive color naming blocks with a 2 (Condition: Baseline, Proactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on diagnostic items for older adults.

6.2 Color Naming ISPC Effect

6.2.1 Color Naming ISPC x AgeCat

$$RT = Condition\ x\ TrialType\ x\ Age + \left(1 + Condition\ x\ TrialType \mid ID\right)$$

Table 5: ISPC x Age Interaction for Inducer Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	25,678,568	25,678,568	1	370.17	2,476.06	0.000
Condition	3,013,113	3,013,113	1	363.82	290.54	0.000
Age	69,079	34,539	2	380.19	3.33	0.037
Trial Type:Condition	7,165,139	7,165,139	1	360.73	690.90	0.000
Trial Type:Age	13,790	6,895	2	370.14	0.66	0.515
Condition:Age	84,039	42,019	2	363.81	4.05	0.018
Trial Type:Condition:Age	10,181	5,091	2	360.63	0.49	0.613

Note. To assess reactive control, we compared baseline and reactive color naming blocks with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Baseline, Reactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on inducer items. Age was a between-subject variable.

6.2.2 Color Naming ISPC within Age Groups

Table 6: ISPC x Age Interaction for Inducer Items during Color Naming Blocks with Younger Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	7,545,104	7,545,104	1	147.68	629.06	0.000
Condition	3,356,068	3,356,068	1	17,818.54	279.80	0.000
Trial Type:Condition	4,947,256	4,947,256	1	17,892.21	412.47	0.000

Note. We also compared baseline and reactive color naming blocks with a 2 (Condition: Baseline, Reactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on inducer items for younger adults.

Table 7: ISPC x Age Interaction for Inducer Items during Color Naming Blocks with Middle-Aged Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	7,809,547	7,809,547	1	141.30	780.33	0.000
Condition	7,196,701	7,196,701	1	16,215.25	719.09	0.000
Trial Type:Condition	4,904,553	4,904,553	1	16,284.04	490.06	0.000

Note. We also compared baseline and reactive color naming blocks with a 2 (Condition: Baseline, Reactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on inducer items for middle-aged adults.

Table 8: ISPC x Age Interaction for Inducer Items during Color Naming Blocks with Older Adults

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Trial Type	5,675,546	5,675,546	1	133.52	567.14	0.000
Condition	4,641,559	4,641,559	1	15,798.09	463.82	0.000
Trial Type:Condition	3,858,754	3,858,754	1	15,825.78	385.59	0.000

Note. We also compared baseline and reactive color naming blocks with a 2 (Condition: Baseline, Reactive) x 2 (Trial Type: Congruent, Incongruent) linear mixed-effect model conducted on inducer items for older adults.

6.3 Color Naming Congruency Cost

6.3.1 Color Naming Congruency Cost x AgeCat

$$RT = Condition\ x\ Age + (1 + Condition \mid ID)$$

Table 9: Congruency Cost x Age Interaction for Diagnostic Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Condition	12,041	12,041	1	371.09	1.29	0.256
Age	11,091	5,546	2	382.35	0.60	0.552
Condition:Age	62,970	31,485	2	371.17	3.38	0.035

Note. To assess congruency cost, we compared reactive and proactive color naming blocks with a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Reactive, Proactive) linear mixed-effect model conducted on diagnostic items. Age was a between-subject variable.

6.4 Color Naming Transfer Cost

6.4.1 Color Naming Reactive Transfer Cost x AgeCat

$$RT = ItemType\ x\ TrialType\ x\ Age + \left(1 + ItemType\ xTrialType \mid ID\right)$$

Table 10: Reactive Transfer Cost x Age Interaction for Diagnostic and Inducer Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Item Type	25,310	25,310	1	371.05	2.47	0.117
Trial Type	13,698,999	13,698,999	1	373.46	1,336.57	0.000
Age	35,436	17,718	2	380.87	1.73	0.179
Item Type:Trial Type	1,321,366	1,321,366	1	360.50	128.92	0.000
Item Type:Age	89,179	44,590	2	371.16	4.35	0.014
Trial Type:Age	2,038	1,019	2	373.52	0.10	0.905
Item Type:Trial Type:Age	35,582	17,791	2	360.64	1.74	0.178

Note. We examined the transfer cost in the reactive condition, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) linear mixed-effect model. Age was a between-subject variable.

6.4.2 Color Naming Proactive Transfer Cost x AgeCat

$$RT = ItemType\ x\ TrialType\ x\ Age + \left(1 + ItemType\ xTrialType \mid ID\right)$$

Table 11: Proactive Transfer Cost x Age Interaction for Diagnostic and Inducer Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Item Type	1,024,221	1,024,221	1	376.12	101.33	0.000
Trial Type	13,221,037	13,221,037	1	384.86	1,308.01	0.000
Age	12,176	6,088	2	382.16	0.60	0.548
Item Type:Trial Type	1,027,871	1,027,871	1	357.02	101.69	0.000
Item Type:Age	39,361	19,681	2	376.26	1.95	0.144
Trial Type:Age	80,913	40,457	2	384.97	4.00	0.019
Item Type:Trial Type:Age	16,201	8,101	2	357.17	0.80	0.449

Note. We examined the transfer cost in the proactive condition, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) linear mixed-effect model. Age was a between-subject variable.

6.4.3 Color Naming Transfer Cost x Condition x AgeCat

$$RT = ItemType\ x\ TrialType\ x\ Age + \left(1 + ItemType\ xTrialType \mid ID\right)$$

Table 12: Pro-Rea Transfer Cost x Age Interaction for Diagnostic and Inducer Items during Color Naming Blocks

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)
Condition	1,788,850	1,788,850	1	85,961.33	170.08	0.000
Item Type	534,153	534,153	1	384.41	50.79	0.000
Trial Type	17,363,317	17,363,317	1	386.39	1,650.90	0.000
Age	24,281	12,140	2	383.60	1.15	0.316
Condition:Item Type	513,006	513,006	1	86,179.18	48.78	0.000
Condition:Trial Type	531,797	531,797	1	86,095.63	50.56	0.000
Item Type:Trial Type	2,190,009	2,190,009	1	381.69	208.23	0.000
Condition:Age	335,796	167,898	2	85,961.39	15.96	0.000
Item Type:Age	23,875	11,937	2	384.51	1.14	0.322
Trial Type:Age	27,820	13,910	2	386.44	1.32	0.268
Condition:Item Type:Trial Type	41,397	41,397	1	86,173.78	3.94	0.047
Condition:Item Type:Age	171,776	85,888	2	86,177.91	8.17	0.000
Condition:Trial Type:Age	98,501	49,250	2	86,094.50	4.68	0.009
Item Type:Trial Type:Age	3,748	1,874	2	381.83	0.18	0.837
Condition:Item Type:Trial Type:Age	55,693	27,847	2	86,173.21	2.65	0.071

Note. We examined the transfer cost in the proactive versus reactive condition, using a 3 (Age: Younger Adults, Middle-Aged Adults, Older Adults) x 2 (Condition: Proactive, Reactive) x 2 (Trial Type: Congruent, Incongruent) x 2 (Item Type: Inducer, Diagnostic) linear mixed-effect model.