**Supplementary Materials**

***The Role of Age of Arrival and Language Environment Factors in Arabic Heritage Language Development: A Longitudinal Study***

**Figure S1**. Correlation matrix for predictor and outcome variables for Arabic entered in regression models.

A graph with different colored squares

Description automatically generated with medium confidence

**Figure S2**. Correlation matrix for predictor and outcome variables for English entered into regression models.

A graph of different languages

Description automatically generated with medium confidence

**Appendix SA: Output of Binomial Model Predicting Verbatim Responses on SRT**

**Table A1.** Coefficient table of binomial model predicting verbatim responses on SRT including a triple interaction between *Time* (T1, T2, T3), *Language* (Arabic, English), and *AOA* (Young, Old) as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| (Intercept) | 1.490 | 0.262 | 5.669 | <.001 \*\*\* |
| Time\_T2 | 0.714 | 0.115 | 6.185 | <.001 \*\*\* |
| Time\_T3 | -0.682 | 0.140 | -4.866 | <.001 \*\*\* |
| Language\_English | -2.755 | 0.347 | -7.929 | <.001 \*\*\* |
| AOA\_Young | -0.687 | 0.222 | -3.084 | .002 \*\* |
| Time\_T2:Language\_English | 0.241 | 0.136 | 1.761 | .078 **†** |
| Time\_T3:Language\_English | 2.711 | 0.137 | 19.813 | <.001 \*\*\* |
| Time\_T2:AOA\_Young | -0.394 | 0.147 | -2.688 | .007 \*\* |
| Time\_T3:AOA\_Young | -0.072 | 0.176 | -0.412 | .680 |
| Language\_English:AOA\_Young | 0.243 | 0.196 | 1.240 | .215 |
| Time\_T2:Language\_English:AOA\_Young | 0.894 | 0.187 | 4.765 | <.001 \*\*\* |
| Time\_T3:Language\_English:AOA\_Young | 0.689 | 0.189 | 3.640 | <.001 \*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* < .01; † = *p* < .10.

**Table A2.** Random effects of A1 model. Random effects included two intercepts, by Item and Participant (nested within Family), and two by-Participant slopes, Time and Language.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. | Corr |  |  |
| Participant:Family | (Intercept) | 1.037 | 1.018 |  |  |  |
|  | Time\_T2 | 0.065 | 0.256 | 0.09 |  |  |
|  | Time\_T3 | 0.259 | 0.509 | -0.45 | 0.57 |  |
|  | Language\_English | 0.250 | 0.500 | 0.03 | 0.01 | -0.19 |
| Family | (Intercept) | 0.494 | 0.703 |  |  |  |
|  | Time\_T2 | 0.087 | 0.294 | 0.20 |  |  |
|  | Time\_T3 | 0.277 | 0.526 | -0.29 | 0.71 |  |
|  | Language\_English | 1.977 | 1.406 | -0.52 | -0.63 | -0.59 |
| Item | (Intercept) | 1.171 | 1.082 |  |  |  |

*Note*. Model run on 21213 observations.

**Table A3.** Pairwise comparisons of A1 model per Language for each level of AOA and Time.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Old, Time = T1 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | 2.755 | 0.347 | 7.929 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Young, Time = T1 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | 2.512 | 0.347 | 7.228 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Old, Time = T2 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | 2.515 | 0.348 | 7.219 | <.001 \*\*\* |
|  | | | | |
| AOA Group: Young, Time = T2 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | 1.378 | 0.343 | 4.008 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Old, Time = T3 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | 0.044 | 0.347 | 0.127 | .899 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Young, Time = T3 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Arabic-English | -0.889 | 0.344 | -2.581 | .010 \* |

*Note. \*\**\* = *p* < .001; *\** = *p* < .05.

**Table A4.** Pairwise comparisons of A1 model per AOA group for each Language and Time.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = Arabic, Time = T1 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | 0.687 | 0.222 | 3.084 | .002 \*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = English, Time = T1 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | 0.443 | 0.259 | 1.710 | .087 † |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = Arabic, Time = T2 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | 1.081 | 0.237 | 4.566 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = English, Time = T2 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | -0.056 | 0.255 | -0.220 | .825 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = Arabic, Time = T3 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | 0.759 | 0.203 | 3.732 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = English, Time = T3 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | -0.171 | 0.218 | -0.797 | .425 |

*Note. \*\**\* = *p* < .001; *\**\* = *p* < .01;\* = *p* < .05; † = *p* < .10.

**Table A5.** Pairwise comparisons of A1 model per Time for each Language and AOA group.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = Arabic, AOA = Old AOA | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 – T2 | -0.714 | 0.115 | -6.185 | <.001 \*\*\* |
| T1 – T3 | 0.682 | 0.140 | 4.866 | <.001 \*\*\* |
| T2 – T3 | 1.396 | 0.131 | 10.661 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = Arabic, AOA = Young AOA | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 – T2 | -0.320 | 0.104 | -3.071 | .006 \*\* |
| T1 – T3 | 0.754 | 0.133 | 5.660 | <.001 \*\*\* |
| T2 – T3 | 1.074 | 0.119 | 9.011 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = English, AOA = Old AOA | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 – T2 | -0.954 | 0.108 | -8.831 | <.001 \*\*\* |
| T1 – T3 | -2.029 | 0.143 | -14.225 | <.001 \*\*\* |
| T2 – T3 | -1.075 | 0.122 | -8.834 | <.001 \*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language = English, AOA = Young AOA | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 – T2 | -1.454 | 0.112 | -12.965 | <.001 \*\*\* |
| T1 – T3 | -2.646 | 0.143 | -18.452 | <.001 \*\*\* |
| T2 – T3 | -1.192 | 0.118 | -10.145 | <.001 \*\*\* |

*Note. \*\**\* = *p* < .001; *\**\* = *p* < .01.

**Appendix SB: Output of Logistic Models Predicting Vocabulary Scores**

**Table B1.** Coefficient table of logistic model predicting Arabic vocabulary scores, including *Time* (T1, T2, T3) and *AOA* (Young, Old) as predictors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |
| (Intercept) | 1.298 | 0.222 | 5.846 | <.001 \*\*\* |
| Time\_T2 | 0.316 | 0.074 | 4.262 | <.001 \*\*\* |
| Time\_T3 | 0.275 | 0.096 | 2.883 | .004 \*\* |
| AOA\_Young | -0.931 | 0.133 | -6.984 | <.001 \*\*\* |

*Note. \*\**\* = *p* < .001; *\*\** = *p* < .01.

**Table B2.** Random effects of B1 model. Random effects included two intercepts, by Item and Participant (nested within Family), and one by-Participant slope, Time.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. | Corr |  |  |
| Participant:Family | (Intercept) | 0.493 | 0.702 |  |  |  |
|  | Time\_T2 | 0.180 | 0.424 | -0.49 |  |  |
|  | Time\_T3 | 0.464 | 0.681 | -0.51 | 0.59 |  |
| Family | (Intercept) | 0.251 | 0.501 |  |  |  |
|  | Time\_T2 | 0.141 | 0.376 | 0.28 |  |  |
|  | Time\_T3 | 0.196 | 0.443 | 0.19 | 0.57 |  |
| Item | (Intercept) | 2.640 | 1.625 |  |  |  |

*Note*. Model run on 25649 observations.

**Table B3.** Pairwise comparisons of B1 model per Time, with results averaged over AOA groups.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Contrast | Estimate | SE | t.ratio | p.value |
| T1 - T2 | -0.316 | 0.074 | -4.262 | < .001\*\*\* |
| T1 - T3 | -0.275 | 0.095 | -2.883 | .011\* |
| T2 - T3 | 0.041 | 0.084 | 0.482 | .880 |

*Note. \*\*\** = *p* < .001; *\** = *p* < .05.

**Table B4.** Coefficient table of logistic model predicting English vocabulary scores, including Time (T1, T2, T3), AOA group (Young, Old), and the interaction between Time and AOA Group as predictors.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |
| (Intercept) | -0.535 | 0.301 | -1.777 | .076 † |
| Time\_T2 | 0.874 | 0.113 | 7.738 | <.001 \*\*\* |
| Time\_T3 | 1.784 | 0.152 | 11.744 | <.001 \*\*\* |
| AOA\_Young | -0.450 | 0.195 | -2.304 | .021 \* |
| Time\_T2:AOA\_Young | 0.465 | 0.125 | 3.725 | <.001 \*\*\* |
| Time\_T3:AOA\_Young | 0.443 | 0.164 | 2.697 | .007 \*\* |

*Note. \*\**\* = *p* < .001; *\*\** = *p* < .01; *\** = *p* < .05; † = *p* < .10.

**Table B5.** Random effects of B4 model. Random effects included two intercepts, by Item and Participant (nested within Family), and one by-Participant slope, Time.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. | Corr |  |  |
| Participant:Family | (Intercept) | 0.686 | 0.828 |  |  |  |
|  | Time\_T2 | 0.164 | 0.405 | -0.41 |  |  |
|  | Time\_T3 | 0.357 | 0.598 | -0.48 | 0.96 |  |
| Family | (Intercept) | 1.553 | 1.246 |  |  |  |
|  | Time\_T2 | 0.395 | 0.629 | -0.79 |  |  |
|  | Time\_T3 | 0.736 | 0.858 | -0.78 | 0.87 |  |
| Item | (Intercept) | 11.000 | 3.317 |  |  |  |

*Note*. Model run on 43874 observations.

**Table B6.** Pairwise comparisons per Time for each level of AOA for the English vocabulary model.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Young | | | | |
| Contrast | Estimate | SE | t.ratio | p.value |
| T1 - T2 | -1.339 | 0.112 | -11.986 | <.001\*\*\* |
| T1 - T3 | -2.227 | 0.148 | -15.021 | <.001\*\*\* |
| T2 - T3 | -0.888 | 0.088 | -10.135 | <.001\*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Old | | | | |
| Contrast | Estimate | SE | t.ratio | p.value |
| T1 - T2 | -0.874 | 0.113 | -7.738 | <.001\*\*\* |
| T1 - T3 | -1.784 | 0.152 | -11.744 | <.001\*\*\* |
| T2 - T3 | -0.910 | 0.093 | -9.830 | <.001\*\*\* |

*Note. \*\**\* = *p* < .001.

**Table B7.** Pairwise comparisons per AOA for each level of Time for the English vocabulary model.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time = T1 | | | | |
| Contrast | Estimate | SE | t.ratio | p.value |
| Old-Young | -0.450 | 0.195 | 2.304 | .021\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time = T2 | | | | |
| Contrast | Estimate | SE | t.ratio | p.value |
| Old-Young | -0.015 | 0.171 | -0.090 | .928 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time = T3 | | | | |
| Contrast | Estimate | SE | t.ratio | p.value |
| Old-Young | 0.007 | 0.175 | 0.040 | .968 |

*Note.* \* = *p* < .05.

**Appendix SC: Output of Ordinal Model Predicting Language Use between Participants and Parents**

**Table C1.** Coefficient table of ordinal model predicting language use between participants and parents, including *Time* (T1, T2, T3), *AOA* (Young, Old), the interaction between *Time* and *AOA*, and *Interaction type* (Child input from parents, Child output to parents) as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | 0.612 | 0.485 | 1.262 | .207 |
| Time\_T3 | 1.067 | 0.497 | 2.147 | .032\* |
| AOA\_Young | -0.356 | 0.668 | -0.534 | .593 |
| Interaction type\_Child output to parents | 2.302 | 0.314 | 7.321 | <.001\*\*\* |
| Time\_T2:AOA\_Young | 1.531 | 0.694 | 2.207 | .027\* |
| Time\_T3:AOA\_Young | 1.140 | 0.701 | 1.627 | .104 |

*Note.* \*\*\* = *p* < .001; \*\* = *p* < .01; † = *p* < .10.

**Table C2.** Random effects for model C1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 3.285 | 1.813 |

*Note*. Model run on 732 observations.

**Table C3.** Threshold coefficients for model C1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|1.5 | 5.052 | 0.603 | 8.375 |
| 1.5|2 | 5.675 | 0.626 | 9.059 |
| 2|2.5 | 6.879 | 0.679 | 10.132 |
| 2.5|3 | 7.162 | 0.693 | 10.334 |
| 3|3.5 | 7.952 | 0.739 | 10.763 |
| 3.5|4 | 8.040 | 0.745 | 10.798 |
| 4|5 | 9.378 | 0.879 | 10.668 |

**Table C4.** Pairwise comparisons per Time for each level of AOA, averaged over Interaction type.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Young | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 - T2 | -2.143 | 0.502 | -4.265 | .001\*\* |
| T1 - T3 | -2.207 | 0.510 | -4.329 | <.001\*\*\* |
| T2 - T3 | -0.064 | 0.356 | -0.181 | .982 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| AOA Group: Old | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 - T2 | -0.612 | 0.485 | -1.262 | .417 |
| T1 - T3 | -1.067 | 0.497 | -2.147 | .081† |
| T2 - T3 | -0.455 | 0.463 | -0.984 | .587 |

*Note. \*\**\* = *p* < .001; *\*\** = *p* < .01; † = *p* < .10.

**Table C5.** Pairwise comparisons per AOA group for each Time, averaged over Interaction type.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: Time 1 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | 0.356 | 0.668 | 0.534 | .593 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: Time 2 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | -1.175 | 0.553 | -2.125 | .034\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: Time 3 | | | | |
| Contrast | Estimate | SE | z.ratio | p.value |
| Old - Young | -0.784 | 0.550 | -1.426 | .154 |

*Note.* \* = *p* < .05.

**Appendix SD: Output of Ordinal Model Predicting Language Use between Participants and Siblings**

**Table D1.** Coefficient table of ordinal model predicting language use between participants and siblings, including *Time* (T1, T2, T3), *AOA* (Young, Old), and *Interaction type* (Child input from siblings, Child output to siblings) as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | 0.920 | 0.226 | 4.069 | <.001\*\*\* |
| Time\_T3 | 2.907 | 0.244 | 11.902 | <.001\*\*\* |
| AOA\_Young | 0.789 | 0.587 | 1.344 | .179 |
| Interaction type\_Child output to siblings | 0.058 | 0.167 | 0.345 | .730 |

*Note.* \*\*\* = *p* < .001.

**Table D2.** Random effects for model D1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 9.427 | 3.070 |

*Note*. Model run on 732 observations.

**Table D3.** Threshold coefficients for model D1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|1.5 | 2.049 | 0.463 | 4.427 |
| 1.5|2 | 2.476 | 0.468 | 5.293 |
| 2|2.5 | 3.780 | 0.489 | 7.724 |
| 2.5|3 | 4.186 | 0.497 | 8.425 |
| 3|3.5 | 5.725 | 0.528 | 10.839 |
| 3.5|4 | 6.083 | 0.536 | 11.355 |
| 4|4.5 | 7.813 | 0.591 | 13.223 |
| 4.5|5 | 8.329 | 0.610 | 13.650 |

**Table D4.** Pairwise comparisons per Time, averaged over the different AOA groups and Interaction type.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Contrast | Estimate | SE | z.ratio | p.value |
| T1 - T2 | -0.920 | 0.226 | -4.069 | .001\*\* |
| T1 - T3 | -2.910 | 0.244 | -11.902 | <.001\*\*\* |
| T2 - T3 | -1.990 | 0.222 | -8.948 | <.001\*\*\* |

**Appendix SE: Output of Ordinal Model Predicting Frequency of Reading/Writing Activities**

**Table E1.** Coefficient table of ordinal model predicting frequency of reading/writing activities, including *Time* (T1, T2, T3), *Language* (Arabic, English), *AOA* (Young, Old), and the interaction between *Time* and *Language* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | 0.530 | 0.268 | 1.975 | .048\* |
| Time\_T3 | -0.077 | 0.285 | -0.269 | .788 |
| Language\_English | 1.640 | 0.254 | 6.450 | <.001\*\*\* |
| AOA\_Young | -0.427 | 0.193 | -2.214 | .027\* |
| Time\_T2:Language\_English | -0.064 | 0.352 | -0.182 | .855 |
| Time\_T3:Language\_English | 1.199 | 0.374 | 3.208 | .001\*\* |

**Table E2.** Random effects for model E1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 0.497 | 0.705 |

*Note*. Model run on 732 observations.

**Table E3.** Threshold coefficients for model E1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|2 | 0.508 | 0.224 | 2.269 |
| 2|3 | 2.583 | 0.249 | 10.389 |
| 3|4 | 3.938 | 0.278 | 14.187 |
| 4|5 | 5.421 | 0.353 | 15.376 |

**Table E4.** Pairwise comparisons per Time for each Language, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: Arabic |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -0.530 | 0.268 | -1.975 | .119 |
| T1– T3 | 0.077 | 0.285 | 0.269 | .961 |
| T2 – T3 | 0.606 | 0.282 | 2.147 | .081† |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: English |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -0.465 | 0.232 | -2.009 | .110 |
| T1 – T3 | -1.123 | 0.243 | -4.619 | <.001\*\*\* |
| T2 – T3 | -0.657 | 0.243 | -2.700 | .019 \* |

*Note.* \*\*\* = *p* < .001; \* = *p* < .05; † = *p* < .10.

**Table E5.** Pairwise comparisons per Language for each Time, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T1 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -1.640 | 0.254 | -6.450 | <.001\*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T2 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -1.580 | 0.256 | -6.163 | <.001\*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T3 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -2.840 | 0.291 | -9.757 | <.001\*\*\* |

**Appendix SF: Output of Ordinal Model Predicting Frequency of Speaking/Listening Activities**

**Table F1.** Coefficient table of ordinal model predicting frequency of speaking/listening activities, including *Time* (T1, T2, T3), *Language* (Arabic, English), *AOA* (Young, Old), and the interaction between *Time* and *Language* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | -0.772 | 0.223 | -3.461 | <.001\*\*\* |
| Time\_T3 | -0.688 | 0.233 | -2.948 | .003\*\* |
| Language\_English | -0.477 | 0.219 | -2.184 | .029\* |
| AOA\_Young | -0.098 | 0.134 | -0.731 | .465 |
| Time\_T2:Language\_English | 1.376 | 0.317 | 4.345 | <.001\*\*\* |
| Time\_T3:Language\_English | 2.670 | 0.343 | 7.783 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* <. 001; \* = *p* < .05.

**Table F2.** Random effects for model F1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 0.005 | 0.071 |

*Note*. Model run on 732 observations.

**Table F3.** Threshold coefficients for model F1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|2 | -2.146 | 0.195 | -10.993 |
| 2|3 | -0.809 | 0.172 | -4.712 |
| 3|4 | 0.463 | 0.171 | 2.711 |
| 4|5 | 1.586 | 0.187 | 8.473 |

**Table F4.** Pairwise comparisons per Time for each Language, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: Arabic |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | 0.772 | 0.223 | 3.461 | .002\*\* |
| T1 – T3 | 0.688 | 0.233 | 2.948 | .009\*\* |
| T2 – T3 | -0.083 | 0.239 | -0.350 | .935 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: English |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -0.604 | 0.223 | -2.709 | .018\* |
| T1 – T3 | -1.982 | 0.247 | -8.029 | <.001\*\*\* |
| T2 – T3 | -1.378 | 0.244 | -5.651 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* < .01; \* = *p* < .05.

**Table F5.** Pairwise comparisons per Language for each Time, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T1 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | 0.477 | 0.219 | 2.184 | .029\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T2 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -0.899 | 0.227 | -3.954 | <.001\*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T3 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -2.193 | 0.261 | -8.389 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \* = *p* < .05.

**Appendix SG: Output of Ordinal Model Predicting Frequency of Language Use with Friends**

**Table G1.** Coefficient table of ordinal model predicting frequency of language use with friends, including *Time* (T1, T2, T3), *Language* (Arabic, English), *AOA* (Young, Old), and the interaction between *Time* and *Language* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | 0.049 | 0.227 | 0.218 | .827 |
| Time\_T3 | -1.105 | 0.240 | -4.596 | <.001\*\*\* |
| Language\_English | -0.626 | 0.225 | -2.789 | .005\*\* |
| AOA\_Young | -0.273 | 0.151 | -1.802 | .072† |
| Time\_T2:Language\_English | 1.393 | 0.326 | 4.272 | <.001\*\*\* |
| Time\_T3:Language\_English | 2.364 | 0.347 | 6.802 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* <. 01; † = *p* < .10.

**Table G2.** Random effects for model G1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 0.138 | 0.372 |

*Note*. Model run on 732 observations.

**Table G3.** Threshold coefficients for model G1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|2 | -1.287 | 0.189 | -6.810 |
| 2|3 | 0.261 | 0.180 | 1.447 |
| 3|4 | 1.810 | 0.198 | 9.131 |
| 4|5 | 2.821 | 0.232 | 12.152 |

**Table G4.** Pairwise comparisons per Time for each Language, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: Arabic |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -0.049 | 0.227 | -0.218 | .974 |
| T1 – T3 | 1.105 | 0.240 | 4.596 | <.001\*\*\* |
| T2 – T3 | 1.155 | 0.246 | 4.685 | <.001\*\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: English |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -1.442 | 0.235 | -6.133 | <.001\*\*\* |
| T1 – T3 | -1.258 | 0.244 | -5.160 | <.001\*\*\* |
| T2 – T3 | 0.184 | 0.242 | 0.761 | .727 |

*Note.* \*\*\* = *p* < .001.

**Table G5.** Pairwise comparisons per Language for each Time, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T1 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | 0.626 | 0.225 | 2.789 | .005\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T2 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -0.767 | 0.233 | -3.283 | .001\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T3 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -1.737 | 0.259 | -6.707 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* <. 001.

**Appendix SH: Output of Ordinal Model Predicting Frequency of Extracurricular Activities**

**Table H1.** Coefficient table of ordinal model predicting frequency of extracurricular activities, including *Time* (T1, T2, T3), *Language* (Arabic, English), *AOA* (Young, Old), and the interaction between *Time* and *Language* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| Time\_T2 | -0.477 | 0.250 | -1.908 | .056† |
| Time\_T3 | -0.088 | 0.251 | -0.350 | .726 |
| Language\_English | -0.728 | 0.248 | -2.931 | .003\*\* |
| AOA\_Young | -0.314 | 0.231 | -1.355 | .175 |
| Time\_T2:Language\_English | 0.974 | 0.356 | 2.739 | .006\*\* |
| Time\_T3:Language\_English | -2.137 | 0.455 | -4.693 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* <. 01; † = *p* < .10.

**Table H2.** Random effects for model H1. Random effects included an intercept by Participant.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant | (Intercept) | 0.928 | 0.963 |

*Note*. Model run on 729 observations.

**Table H3.** Threshold coefficients for model H1.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Estimate | Std. Error | z value |
| 1|2 | -0.559 | 0.223 | -2.505 |
| 2|3 | 1.299 | 0.229 | 5.660 |
| 3|4 | 2.718 | 0.270 | 10.052 |
| 4|5 | 3.627 | 0.332 | 10.935 |

**Table H4.** Pairwise comparisons per Time for each Language, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: Arabic |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | 0.477 | 0.250 | 1.908 | .136 |
| T1 – T3 | 0.088 | 0.251 | 0.350 | .935 |
| T2 – T3 | -0.389 | 0.264 | -1.474 | .304 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Language: English |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| T1 – T2 | -0.497 | 0.254 | -1.960 | .122 |
| T1 – T3 | 2.225 | 0.382 | 5.821 | <.001\*\*\* |
| T2 – T3 | 2.722 | 0.381 | 7.149 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001.

**Table H5.** Pairwise comparisons per Language for each Time, averaged over AOA.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T1 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | 0.728 | 0.248 | 2.931 | .003\*\* |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T2 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | -0.247 | 0.255 | -0.970 | .332 |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Time: T3 |  |  |  |  |
|  | Contrast | SE | z.ratio | Pr(>|z|) |
| Arabic – English | 2.865 | 0.389 | 7.373 | <.001\*\*\* |

*Note.* \*\*\* = *p* < .001; \*\* = *p* <. 01.

**Appendix SI: Output of Logistic Models Predicting Accuracy in the Arabic SRT**

**Table I1.** Coefficient table of logistic model predicting the accuracy in SRT at T3 with concurrent T3 predictors, including *Language use with siblings, Length of Arabic schooling,* *Hours of speaking/listening activities in Arabic, Hours spent interacting with friends in Arabic*, and *Hours of Arabic extracurricular activities* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| (Intercept) | 0.451 | 0.237 | 1.907 | .057† |
| Language use with siblings | -0.306 | 0.140 | -2.191 | .028\* |
| Length of Arabic schooling | 0.367 | 0.125 | 2.931 | .003\*\* |
| Hours of speaking/listening activities in Arabic | 0.260 | 0.142 | 1.826 | .068† |
| Hours spent interacting with friends in Arabic | 0.354 | 0.145 | 2.444 | .015\* |
| Hours of Arabic extracurricular activities | -0.315 | 0.136 | -2.312 | .021\* |

*Note.* \*\* = *p* <. 01; \* = *p* < .05; † = *p* < .10.

**Table I2.** Random effects of I1 model. Random effects included an intercept by Item and one by Participant nested within Family.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant:Family | (Intercept) | 1.001 | 1.001 |
| Family | (Intercept) | 0.276 | 0.525 |
| Item | (Intercept) | 1.219 | 1.104 |

*Note*. Model run on 3198 observations.

**Table I3.** Coefficient table of logistic model predicting the accuracy in SRT at T3 with T2 predictors, including *Language use with siblings at T2*, *Hours of Arabic extracurricular activities at T2, and Length of Arabic schooling* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| (Intercept) | 0.426 | 0.246 | 1.735 | .083† |
| Language use with siblings – T2 | -0.355 | 0.144 | -2.459 | .014\* |
| Hours of Arabic extracurricular activities – T2 | 0.230 | 0.139 | 1.655 | .098† |
| Length of Arabic schooling | 0.369 | 0.134 | 2.764 | .006\*\* |

*Note.* \*\* = *p* <. 01; \* = *p* < .05; † = *p* < .10.

**Table I4.** Random effects of I3 model. Random effects included an intercept by Item and one by Participant nested within Family.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant:Family | (Intercept) | 1.097 | 1.047 |
| Family | (Intercept) | 0.453 | 0.673 |
| Item | (Intercept) | 1.214 | 1.102 |

*Note*. Model run on 3112 observations.

**Appendix SJ: Output of Logistic Models Predicting Accuracy in the Arabic Vocabulary Task**

**Table J1.** Coefficient table of logistic model predicting the accuracy in vocabulary task at T3 with concurrent T3 predictors, including *Language use with siblings* and *Length of Arabic schooling* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | t value | Pr(>|t|) |
| (Intercept) | 1.034 | 0.207 | 5.008 | <.001\*\*\* |
| Language use with siblings | -0.350 | 0.098 | -3.561 | <.001\*\*\* |
| Length of Arabic schooling | 0.434 | 0.090 | 4.792 | <.001\*\*\* |

*Note. \**\*\* = *p* <. 001.

**Table J2.** Random effects of model J1. Random effects included an intercept by Item and one by Participant nested within Family.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant:Family | (Intercept) | 0.472 | 0.687 |
| Family | (Intercept) | 0.290 | 0.539 |
| Item | (Intercept) | 2.365 | 1.538 |

*Note*. Model run on 7947 observations.

**Table J3.** Coefficient table of logistic model predicting the accuracy in vocabulary task at T3 with T2 predictors, including *Language use with siblings at T2, Hours of Arabic extracurricular activities at T2*, and *Length of Arabic schooling* as fixed effects.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Estimate | Std. Error | z value | Pr(>|z|) |
| (Intercept) | 1.027 | 0.208 | 4.934 | <.001\*\*\* |
| Language use with siblings – T2 | -0.310 | 0.102 | -3.032 | .002\*\* |
| Hours of Arabic extracurricular activities – T2 | 0.237 | 0.099 | 2.395 | .017\* |
| Length of Arabic schooling | 0.434 | 0.093 | 4.659 | <.001\*\*\* |

*Note. \**\*\* = *p* <. 001; \*\* = *p* < .01; \* = *p* < .05.

**Table J4.** Random effects of J3 model. Random effects included an intercept by Item and one by Participant nested within Family.

|  |  |  |  |
| --- | --- | --- | --- |
| Groups | Name | Variance | Std.Dev. |
| Participant:Family | (Intercept) | 0.458 | 0.677 |
| Family | (Intercept) | 0.340 | 0.583 |
| Item | (Intercept) | 2.347 | 1.532 |

*Note*. Model run on 7818 observations.