# APPENDIX A. ACOUSTIC MEASURES OF LEXICAL TONES IN EACH LANGUAGE, AND IMITATIONS OF THE THAI TONES

Table A.1 Acoustic measures of tones in Thai (20 tokens per tone), Mandarin and Vietnamese (32 tokens per tone). F0mean, F0excursion, are Lobanov-normalised Hz scores (Lobanov, 1971). CI = Confidence Interval, for which LL = Lower Limit, UL = Upper limit.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Duration (ms) | | | F0mean | | | F0excursion | | | F0maxloc | | |
| Tones | Mean | 95% CI | | Mean | 95% CI | | Mean | 95% CI | | Mean | 95% CI | |
|  |  | LL | UL |  | LL | UL |  | LL | UL |  | LL | UL |
| **Thai:**  T45 | 619 | 597 | 641 | 0.05 | 0.03 | 0.07 | 0.17 | 0.15 | 0.19 | 1.00 | 0.99 | 1.00 |
| T33 | 640 | 613 | 667 | -0.01 | -0.04 | 0.02 | 0.11 | 0.09 | 0.13 | 0.34 | 0.27 | 0.42 |
| T21 | 622 | 598 | 646 | -0.10 | -0.11 | -0.08 | 0.22 | 0.19 | 0.25 | 0.22 | 0.19 | 0.24 |
| T315 | 642 | 616 | 669 | -0.08 | -0.10 | -0.07 | 0.19 | 0.16 | 0.22 | 0.72 | 0.59 | 0.85 |
| T241 | 565 | 533 | 597 | 0.13 | 0.11 | 0.15 | 0.21 | 0.18 | 0.24 | 0.53 | 0.49 | 0.58 |
| **Mandarin:**  M55 | 663 | 628 | 697 | 0.14 | 0.13 | 0.15 | 0.09 | 0.08 | 0.10 | 0.74 | 0.67 | 0.81 |
| M35 | 613 | 587 | 640 | -0.05 | -0.07 | -0.04 | 0.30 | 0.29 | 0.32 | 0.99 | 0.99 | 1.00 |
| M51 | 506 | 474 | 538 | 0.08 | 0.07 | 0.10 | 0.44 | 0.39 | 0.49 | 0.29 | 0.26 | 0.32 |
| M214 | 745 | 711 | 779 | -0.23 | -0.26 | -0.21 | 0.43 | 0.37 | 0.50 | 0.42 | 0.34 | 0.50 |
| **Vietnamese:** |  |  |  |  |  |  |  |  |  |  |  |  |
| V44 | 469 | 460 | 479 | 0.08 | 0.07 | 0.09 | 0.16 | 0.14 | 0.19 | 0.58 | 0.50 | 0.65 |
| V22 | 501 | 491 | 511 | -0.11 | -0.12 | -0.10 | 0.17 | 0.16 | 0.19 | 0.16 | 0.14 | 0.18 |
| V35 | 465 | 455 | 475 | 0.19 | 0.18 | 0.21 | 0.44 | 0.42 | 0.47 | 1.00 | 0.99 | 1.00 |
| V21 | 456 | 446 | 466 | -0.17 | -0.18 | -0.15 | 0.26 | 0.20 | 0.32 | 0.49 | 0.38 | 0.60 |
| V214 | 488 | 479 | 497 | -0.09 | -0.10 | -0.07 | 0.48 | 0.46 | 0.51 | 1.00 | 1.00 | 1.00 |

Table A.2 Deviation scores of imitations of Thai tones by Mandarin participants by condition.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Thai  tones | Memory  load | Talker  variability | Vowel  variability | Duration | F0mean | F0excursion | F0maxloc |
| T45 | High | VariableT | VariableV | 0.022 | -0.007 | 0.078 | -0.09 |
| VariableT | ConstantV | 0.021 | -0.008 | 0.105 | -0.071 |
| ConstantT | VariableV | 0 | -0.013 | 0.106 | -0.074 |
| ConstantT | ConstantV | 0 | -0.01 | 0.091 | -0.085 |
| Low | VariableT | VariableV | 0.018 | -0.031 | 0.07 | -0.058 |
| VariableT | ConstantV | 0.017 | -0.032 | 0.061 | -0.062 |
| ConstantT | VariableV | -0.013 | -0.035 | 0.065 | -0.045 |
| ConstantT | ConstantV | -0.007 | -0.032 | 0.054 | -0.056 |
| T33 | High | VariableT | VariableV | 0.052 | -0.01 | 0.132 | 0.061 |
| VariableT | ConstantV | 0.072 | -0.011 | 0.151 | 0.064 |
| ConstantT | VariableV | 0.066 | -0.009 | 0.162 | -0.065 |
| ConstantT | ConstantV | 0.053 | -0.02 | 0.133 | -0.074 |
| Low | VariableT | VariableV | 0.081 | -0.007 | 0.083 | 0.033 |
| VariableT | ConstantV | 0.063 | -0.009 | 0.08 | 0.018 |
| ConstantT | VariableV | 0.062 | -0.012 | 0.101 | -0.116 |
| ConstantT | ConstantV | 0.061 | -0.012 | 0.075 | -0.07 |
| T21 | High | VariableT | VariableV | -0.042 | -0.001 | 0.055 | 0.008 |
| VariableT | ConstantV | -0.038 | -0.004 | 0.055 | 0.003 |
| ConstantT | VariableV | 0.007 | -0.004 | 0.062 | 0.061 |
| ConstantT | ConstantV | -0.001 | -0.014 | 0.059 | 0.034 |
| Low | VariableT | VariableV | -0.023 | 0.015 | 0.039 | 0.009 |
| VariableT | ConstantV | -0.037 | 0.008 | 0.023 | -0.004 |
| ConstantT | VariableV | 0.017 | 0.003 | 0.06 | 0.038 |
| ConstantT | ConstantV | 0.01 | -0.007 | 0.069 | 0.022 |
| T315 | High | VariableT | VariableV | -0.024 | 0.06 | 0.207 | 0.174 |
| VariableT | ConstantV | -0.024 | 0.055 | 0.212 | 0.171 |
| ConstantT | VariableV | -0.029 | 0.056 | 0.202 | -0.03 |
| ConstantT | ConstantV | -0.02 | 0.055 | 0.212 | -0.02 |
| Low | VariableT | VariableV | -0.029 | 0.034 | 0.136 | 0.138 |
| VariableT | ConstantV | -0.016 | 0.037 | 0.146 | 0.136 |
| ConstantT | VariableV | -0.015 | 0.036 | 0.133 | -0.034 |
| ConstantT | ConstantV | -0.024 | 0.036 | 0.118 | -0.03 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T241 | High | VariableT | VariableV | 0.064 | -0.051 | 0.115 | -0.141 |
| VariableT | ConstantV | 0.063 | -0.044 | 0.133 | -0.147 |
| ConstantT | VariableV | 0.074 | -0.023 | 0.105 | -0.167 |
| ConstantT | ConstantV | 0.056 | -0.024 | 0.118 | -0.196 |
| Low | VariableT | VariableV | 0.056 | -0.047 | 0.068 | -0.137 |
| VariableT | ConstantV | 0.045 | -0.049 | 0.088 | -0.163 |
| ConstantT | VariableV | 0.061 | -0.025 | 0.089 | -0.208 |
| ConstantT | ConstantV | 0.046 | -0.031 | 0.098 | -0.181 |

Table A.3 Deviation scores of imitations of Thai tones by Vietnamese participants by condition.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Thai  tones | Memory  load | Talker  variability | Vowel  variability | Duration | F0mean | F0excursion | F0maxloc |
| T45 | High | VariableT | VariableV | 0.031 | -0.048 | 0.04 | -0.081 |
| VariableT | ConstantV | 0.013 | -0.034 | 0.06 | -0.093 |
| ConstantT | VariableV | 0.008 | -0.046 | 0.054 | -0.074 |
| ConstantT | ConstantV | 0.004 | -0.039 | 0.052 | -0.096 |
| Low | VariableT | VariableV | 0.029 | -0.036 | 0.052 | -0.107 |
| VariableT | ConstantV | 0.031 | -0.041 | 0.062 | -0.119 |
| ConstantT | VariableV | 0.017 | -0.03 | 0.061 | -0.088 |
| ConstantT | ConstantV | 0.007 | -0.028 | 0.069 | -0.111 |
| T33 | High | VariableT | VariableV | 0.088 | -0.028 | 0.098 | 0.01 |
| VariableT | ConstantV | 0.057 | -0.027 | 0.096 | -0.027 |
| ConstantT | VariableV | 0.054 | -0.041 | 0.109 | -0.156 |
| ConstantT | ConstantV | 0.056 | -0.026 | 0.113 | -0.12 |
| Low | VariableT | VariableV | 0.053 | -0.012 | 0.084 | 0.018 |
| VariableT | ConstantV | 0.063 | -0.019 | 0.085 | -0.02 |
| ConstantT | VariableV | 0.066 | -0.014 | 0.092 | -0.138 |
| ConstantT | ConstantV | 0.049 | -0.023 | 0.082 | -0.117 |
| T21 | High | VariableT | VariableV | -0.02 | 0.005 | -0.006 | 0 |
| VariableT | ConstantV | -0.011 | 0.006 | -0.006 | 0.027 |
| ConstantT | VariableV | 0.029 | -0.01 | 0.022 | 0.027 |
| ConstantT | ConstantV | 0.032 | -0.008 | 0.011 | 0.024 |
| Low | VariableT | VariableV | -0.036 | 0.008 | -0.024 | -0.013 |
| VariableT | ConstantV | -0.029 | 0.002 | -0.001 | -0.018 |
| ConstantT | VariableV | 0.01 | -0.005 | 0.006 | 0.006 |
| ConstantT | ConstantV | 0 | -0.001 | 0.006 | -0.003 |
| T315 | High | VariableT | VariableV | -0.042 | 0.052 | 0.255 | 0.202 |
| VariableT | ConstantV | -0.052 | 0.058 | 0.28 | 0.173 |
| ConstantT | VariableV | -0.051 | 0.045 | 0.224 | -0.026 |
| ConstantT | ConstantV | -0.058 | 0.061 | 0.224 | -0.038 |
| Low | VariableT | VariableV | -0.028 | 0.046 | 0.253 | 0.193 |
| VariableT | ConstantV | -0.026 | 0.046 | 0.242 | 0.192 |
| ConstantT | VariableV | -0.019 | 0.031 | 0.245 | -0.025 |
| ConstantT | ConstantV | -0.016 | 0.033 | 0.228 | -0.02 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| T241 | High | VariableT | VariableV | 0.064 | -0.033 | 0.051 | -0.111 |
| VariableT | ConstantV | 0.048 | -0.025 | 0.042 | -0.102 |
| ConstantT | VariableV | 0.066 | -0.009 | 0.054 | -0.188 |
| ConstantT | ConstantV | 0.05 | -0.015 | 0.048 | -0.176 |
| Low | VariableT | VariableV | 0.047 | -0.036 | 0.002 | -0.125 |
| VariableT | ConstantV | 0.044 | -0.036 | -0.001 | -0.093 |
| ConstantT | VariableV | 0.064 | -0.005 | 0.008 | -0.18 |
| ConstantT | ConstantV | 0.046 | -0.006 | 0.008 | -0.171 |

# APPENDIX B. STATISTICAL ANALYSIS OF MANDARIN IMITATION DATA.

Table B.1 Comparisons of each imitated Thai tone with other tones for each acoustic measure by Mandarin participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold. SE = Standard Error of the Mean.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Contrasts | *d* | Estimates | *SE* | *df* | *t* | *p* |
| Duration | T45 - T315 | 0.258 | 0.030 | 0.005 | 5026 | 5.82 | **<.001** |
| Duration | T45 - T241 | -0.438 | -0.051 | 0.005 | 5026 | -9.88 | **<.001** |
| Duration | T33 - T45 | 0.485 | 0.056 | 0.005 | 5026 | 10.95 | **<.001** |
| Duration | T33 - T315 | 0.743 | 0.086 | 0.005 | 5026 | 16.79 | **<.001** |
| Duration | T33 - T241 | 0.047 | 0.006 | 0.005 | 5026 | 1.07 | 0.822 |
| Duration | T21 - T45 | -0.178 | -0.021 | 0.005 | 5026 | -4.02 | **0.001** |
| Duration | T21 - T33 | -0.664 | -0.077 | 0.005 | 5026 | -14.98 | **<.001** |
| Duration | T21 - T315 | 0.079 | 0.009 | 0.005 | 5026 | 1.79 | 0.377 |
| Duration | T21 - T241 | -0.616 | -0.072 | 0.005 | 5026 | -13.91 | **<.001** |
| Duration | T241 - T315 | 0.696 | 0.081 | 0.005 | 5026 | 15.71 | **<.001** |
| F0mean | T45 - T241 | 0.249 | 0.016 | 0.003 | 5026 | 5.61 | **<.001** |
| F0mean | T45 - T315 | -1.066 | -0.067 | 0.003 | 5026 | -24.08 | **<.001** |
| F0mean | T33 - T45 | 0.155 | 0.010 | 0.003 | 5026 | 3.49 | **0.004** |
| F0mean | T33 - T315 | -0.911 | -0.057 | 0.003 | 5026 | -20.58 | **<.001** |
| F0mean | T33 - T241 | 0.403 | 0.025 | 0.003 | 5026 | 9.1 | **<.001** |
| F0mean | T21 - T45 | 0.328 | 0.021 | 0.003 | 5026 | 7.41 | **<.001** |
| F0mean | T21 - T33 | 0.174 | 0.011 | 0.003 | 5026 | 3.92 | **0.001** |
| F0mean | T21 - T315 | -0.738 | -0.046 | 0.003 | 5026 | -16.66 | **<.001** |
| F0mean | T21 - T241 | 0.577 | 0.036 | 0.003 | 5026 | 13.02 | **<.001** |
| F0mean | T241 - T315 | -1.315 | -0.083 | 0.003 | 5026 | -29.69 | **<.001** |
| F0excursion | T45 - T315 | -0.645 | -0.092 | 0.006 | 5026 | -14.56 | **<.001** |
| F0excursion | T45 - T241 | -0.163 | -0.023 | 0.006 | 5026 | -3.67 | **0.002** |
| F0excursion | T33 - T45 | 0.252 | 0.036 | 0.006 | 5026 | 5.68 | **<.001** |
| F0excursion | T33 - T315 | -0.393 | -0.056 | 0.006 | 5026 | -8.87 | **<.001** |
| F0excursion | T33 - T241 | 0.089 | 0.013 | 0.006 | 5026 | 2.01 | 0.26 |
| F0excursion | T21 - T45 | -0.179 | -0.026 | 0.006 | 5026 | -4.05 | **0.001** |
| F0excursion | T21 - T33 | -0.431 | -0.062 | 0.006 | 5026 | -9.73 | **<.001** |
| F0excursion | T21 - T315 | -0.824 | -0.118 | 0.006 | 5026 | -18.62 | **<.001** |
| F0excursion | T21 - T241 | -0.342 | -0.049 | 0.006 | 5026 | -7.72 | **<.001** |
| F0excursion | T241 - T315 | -0.482 | -0.069 | 0.006 | 5026 | -10.89 | **<.001** |
| F0maxloc | T45 - T315 | -0.642 | -0.131 | 0.009 | 5026 | -14.5 | **<.001** |
| F0maxloc | T45 - T241 | 0.49 | 0.1 | 0.009 | 5026 | 11.06 | **<.001** |
| F0maxloc | T33 - T45 | 0.241 | 0.049 | 0.009 | 5026 | 5.44 | **<.001** |
| F0maxloc | T33 - T315 | -0.401 | -0.082 | 0.009 | 5026 | -9.05 | **<.001** |
| F0maxloc | T33 - T241 | 0.732 | 0.149 | 0.009 | 5026 | 16.51 | **<.001** |
| F0maxloc | T21 - T45 | 0.437 | 0.089 | 0.009 | 5026 | 9.85 | **<.001** |
| F0maxloc | T21 - T33 | 0.195 | 0.04 | 0.009 | 5026 | 4.41 | **<.001** |
| F0maxloc | T21 - T315 | -0.205 | -0.042 | 0.009 | 5026 | -4.64 | **<.001** |
| F0maxloc | T21 - T241 | 0.927 | 0.189 | 0.009 | 5026 | 20.92 | **<.001** |
| F0maxloc | T241 - T315 | -1.132 | -0.231 | 0.009 | 5026 | -25.58 | **<.001** |

Table B.2 Comparisons of high versus low memory load on imitations of each Thai tone and each acoustic measure by Mandarin participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Thai tone | *d* | Estimate | *SE* | *df* | *t* | *p* |
| F0mean | T45 | 0.364 | 0.023 | 0.005 | 138 | 4.75 | **<.001** |
| F0mean | T33 | -0.040 | -0.003 | 0.005 | 138 | -0.53 | 1.000 |
| F0mean | T21 | -0.167 | -0.010 | 0.005 | 138 | -2.17 | 0.479 |
| F0mean | T315 | 0.330 | 0.021 | 0.005 | 137 | 4.32 | **0.001** |
| F0mean | T241 | 0.042 | 0.003 | 0.005 | 138 | 0.54 | 1.000 |
| F0excursion | T45 | 0.231 | 0.033 | 0.024 | 38 | 1.36 | 0.931 |
| F0excursion | T33 | 0.421 | 0.060 | 0.024 | 38 | 2.49 | 0.308 |
| F0excursion | T21 | 0.072 | 0.010 | 0.024 | 38 | 0.42 | 1.000 |
| F0excursion | T315 | 0.522 | 0.075 | 0.024 | 38 | 3.08 | 0.095 |
| F0excursion | T241 | 0.225 | 0.032 | 0.024 | 38 | 1.33 | 0.941 |
| F0maxloc | T45 | -0.123 | -0.025 | 0.021 | 60 | -1.19 | 0.971 |
| F0maxloc | T33 | 0.151 | 0.031 | 0.021 | 60 | 1.46 | 0.901 |
| F0maxloc | T21 | 0.051 | 0.010 | 0.021 | 60 | 0.49 | 1.000 |
| F0maxloc | T315 | 0.106 | 0.022 | 0.021 | 60 | 1.03 | 0.989 |
| F0maxloc | T241 | 0.045 | 0.009 | 0.021 | 60 | 0.43 | 1.000 |

Table B.3 Comparisons of constant versus variable talker blocks on imitations of each Thai tone and each acoustic measure by Mandarin participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Thai tones | *d* | Estimate | *SE* | *df* | *t* | *p* |
| Duration | T45 | 0.213 | 0.025 | 0.007 | 5026 | 3.39 | **0.024** |
| Duration | T33 | 0.054 | 0.006 | 0.007 | 5026 | 0.87 | 0.997 |
| Duration | T21 | -0.372 | -0.043 | 0.007 | 5026 | -5.94 | **<.001** |
| Duration | T315 | -0.012 | -0.001 | 0.007 | 5026 | -0.20 | 1.000 |
| Duration | T241 | -0.019 | -0.002 | 0.007 | 5026 | -0.30 | 1.000 |
| F0mean | T45 | 0.043 | 0.003 | 0.004 | 5026 | 0.69 | 1.000 |
| F0mean | T33 | 0.062 | 0.004 | 0.004 | 5026 | 0.99 | 0.993 |
| F0mean | T21 | 0.159 | 0.010 | 0.004 | 5026 | 2.54 | 0.249 |
| F0mean | T315 | 0.011 | 0.001 | 0.004 | 5026 | 0.18 | 1.000 |
| F0mean | T241 | -0.356 | -0.022 | 0.004 | 5026 | -5.67 | **<.001** |
| F0excursion | T45 | -0.003 | 0 | 0.009 | 5026 | -0.04 | 1.000 |
| F0excursion | T33 | -0.043 | -0.006 | 0.009 | 5026 | -0.69 | 1.000 |
| F0excursion | T21 | -0.136 | -0.02 | 0.009 | 5026 | -2.18 | 0.474 |
| F0excursion | T315 | 0.063 | 0.009 | 0.009 | 5026 | 1.00 | 0.992 |
| F0excursion | T241 | -0.012 | -0.002 | 0.009 | 5026 | -0.19 | 1.000 |
| F0maxloc | T45 | -0.024 | -0.005 | 0.013 | 5026 | -0.38 | 1.000 |
| F0maxloc | T33 | 0.617 | 0.126 | 0.013 | 5026 | 9.84 | **<.001** |
| F0maxloc | T21 | -0.171 | -0.035 | 0.013 | 5026 | -2.73 | 0.163 |
| F0maxloc | T315 | 0.900 | 0.183 | 0.013 | 5026 | 14.4 | **<.001** |
| F0maxloc | T241 | 0.201 | 0.041 | 0.013 | 5026 | 3.21 | **0.044** |

# APPENDIX C. STATISTICAL ANALYSIS OF VIETNAMESE DATA

# Table C.1 Comparisons of each imitated Thai tone with other tones for each acoustic measure by Vietnamese participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Contrasts | *d* | Estimates | *SE* | *df* | *t* | *p* |
| Duration | T45 - T315 | 0.478 | 0.054 | 0.005 | 5019 | 10.79 | **<.001** |
| Duration | T45 - T241 | -0.321 | -0.036 | 0.005 | 5019 | -7.23 | **<.001** |
| Duration | T33 - T45 | 0.384 | 0.043 | 0.005 | 5019 | 8.66 | **<.001** |
| Duration | T33 - T315 | 0.862 | 0.097 | 0.005 | 5019 | 19.46 | **<.001** |
| Duration | T33 - T241 | 0.063 | 0.007 | 0.005 | 5019 | 1.42 | 0.614 |
| Duration | T21 - T45 | -0.182 | -0.021 | 0.005 | 5019 | -4.10 | **<.001** |
| Duration | T21 - T33 | -0.565 | -0.064 | 0.005 | 5019 | -12.76 | **<.001** |
| Duration | T21 - T315 | 0.297 | 0.034 | 0.005 | 5019 | 6.69 | **<.001** |
| Duration | T21 - T241 | -0.502 | -0.057 | 0.005 | 5019 | -11.32 | **<.001** |
| Duration | T241 - T315 | 0.799 | 0.090 | 0.005 | 5019 | 18.01 | **<.001** |
| F0mean | T45 - T315 | -1.385 | -0.084 | 0.003 | 5019 | -31.24 | **<.001** |
| F0mean | T45 - T241 | -0.280 | -0.017 | 0.003 | 5019 | -6.32 | **<.001** |
| F0mean | T33 - T45 | 0.227 | 0.014 | 0.003 | 5019 | 5.13 | **<.001** |
| F0mean | T33 - T315 | -1.158 | -0.070 | 0.003 | 5019 | -26.13 | **<.001** |
| F0mean | T33 - T241 | -0.053 | -0.003 | 0.003 | 5019 | -1.20 | 0.754 |
| F0mean | T21 - T45 | 0.614 | 0.037 | 0.003 | 5019 | 13.86 | **<.001** |
| F0mean | T21 - T33 | 0.387 | 0.024 | 0.003 | 5019 | 8.73 | **<.001** |
| F0mean | T21 - T315 | -0.771 | -0.047 | 0.003 | 5019 | -17.38 | **<.001** |
| F0mean | T21 - T241 | 0.334 | 0.020 | 0.003 | 5019 | 7.53 | **<.001** |
| F0mean | T241 - T315 | -1.105 | -0.067 | 0.003 | 5019 | -24.89 | **<.001** |
| F0excursion | T45 - T315 | -1.477 | -0.187 | 0.006 | 5019 | -33.31 | **<.001** |
| F0excursion | T45 - T241 | 0.237 | 0.030 | 0.006 | 5019 | 5.33 | **<.001** |
| F0excursion | T33 - T45 | 0.301 | 0.038 | 0.006 | 5019 | 6.81 | **<.001** |
| F0excursion | T33 - T315 | -1.175 | -0.149 | 0.006 | 5019 | -26.53 | **<.001** |
| F0excursion | T33 - T241 | 0.538 | 0.068 | 0.006 | 5019 | 12.14 | **<.001** |
| F0excursion | T21 - T45 | -0.436 | -0.055 | 0.006 | 5019 | -9.84 | **<.001** |
| F0excursion | T21 - T33 | -0.738 | -0.094 | 0.006 | 5019 | -16.65 | **<.001** |
| F0excursion | T21 - T315 | -1.913 | -0.243 | 0.006 | 5019 | -43.13 | **<.001** |
| F0excursion | T21 - T241 | -0.200 | -0.025 | 0.006 | 5019 | -4.50 | **<.001** |
| F0excursion | T241 - T315 | -1.713 | -0.217 | 0.006 | 5019 | -38.61 | **<.001** |
| F0maxloc | T45 - T315 | -0.905 | -0.178 | 0.009 | 5019 | -20.43 | **<.001** |
| F0maxloc | T45 - T241 | 0.241 | 0.047 | 0.009 | 5019 | 5.43 | **<.001** |
| F0maxloc | T33 - T45 | 0.137 | 0.027 | 0.009 | 5019 | 3.09 | **0.017** |
| F0maxloc | T33 - T315 | -0.768 | -0.151 | 0.009 | 5019 | -17.34 | **<.001** |
| F0maxloc | T33 - T241 | 0.378 | 0.074 | 0.009 | 5019 | 8.52 | **<.001** |
| F0maxloc | T21 - T45 | 0.522 | 0.102 | 0.009 | 5019 | 11.77 | **<.001** |
| F0maxloc | T21 - T33 | 0.385 | 0.076 | 0.009 | 5019 | 8.68 | **<.001** |
| F0maxloc | T21 - T315 | -0.384 | -0.075 | 0.009 | 5019 | -8.65 | **<.001** |
| F0maxloc | T21 - T241 | 0.762 | 0.150 | 0.009 | 5019 | 17.18 | **<.001** |
| F0maxloc | T241 - T315 | -1.146 | -0.225 | 0.009 | 5019 | -25.83 | **<.001** |

Table C.2 Comparisons of high versus low memory load on imitations of each Thai tone and each acoustic measure by Vietnamese participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Thai tones | *d* | *Estimate* | *SE* | *df* | *t* | *p* |
| Duration | T45 | -0.060 | -0.007 | 0.007 | 683 | -0.95 | 0.995 |
| Duration | T33 | 0.055 | 0.006 | 0.007 | 681 | 0.87 | 0.997 |
| Duration | T21 | 0.190 | 0.021 | 0.007 | 685 | 3.03 | 0.075 |
| Duration | T315 | -0.251 | -0.028 | 0.007 | 685 | -4.00 | **0.003** |
| Duration | T241 | 0.062 | 0.007 | 0.007 | 687 | 0.98 | 0.993 |
| F0mean | T45 | -0.130 | -0.008 | 0.005 | 139 | -1.69 | 0.798 |
| F0mean | T33 | -0.223 | -0.014 | 0.005 | 138 | -2.92 | 0.109 |
| F0mean | T21 | -0.042 | -0.003 | 0.005 | 139 | -0.55 | 1.000 |
| F0mean | T315 | 0.250 | 0.015 | 0.005 | 139 | 3.26 | **0.044** |
| F0mean | T241 | 0 | 0 | 0.005 | 139 | 0 | 1.000 |
| F0excursion | T45 | -0.071 | -0.009 | 0.017 | 43 | -0.52 | 1.000 |
| F0excursion | T33 | 0.147 | 0.019 | 0.017 | 43 | 1.07 | 0.985 |
| F0excursion | T21 | 0.074 | 0.009 | 0.017 | 43 | 0.54 | 1.000 |
| F0excursion | T315 | 0.035 | 0.004 | 0.017 | 43 | 0.26 | 1.000 |
| F0excursion | T241 | 0.353 | 0.045 | 0.017 | 43 | 2.57 | 0.262 |
| F0maxloc | T45 | 0.108 | 0.021 | 0.024 | 47 | 0.88 | 0.997 |
| F0maxloc | T33 | -0.048 | -0.009 | 0.024 | 47 | -0.39 | 1.000 |
| F0maxloc | T21 | 0.137 | 0.027 | 0.024 | 47 | 1.11 | 0.982 |
| F0maxloc | T315 | -0.033 | -0.006 | 0.024 | 47 | -0.26 | 1.000 |
| F0maxloc | T241 | -0.010 | -0.002 | 0.024 | 48 | -0.08 | 1.000 |

Table C.3 Comparisons of constant versus variable talker blocks on imitations of each tone and for each acoustic measure by Vietnamese participants with Tukey adjustments. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Thai tones | *d* | estimate | *SE* | *df* | *t* | *p* |
| Duration | T45 | 0.152 | 0.017 | 0.007 | 5019 | 2.43 | 0.311 |
| Duration | T33 | 0.080 | 0.009 | 0.007 | 5019 | 1.28 | 0.959 |
| Duration | T21 | -0.372 | -0.042 | 0.007 | 5020 | -5.93 | **<.001** |
| Duration | T315 | -0.009 | -0.001 | 0.007 | 5019 | -0.14 | 1.000 |
| Duration | T241 | -0.055 | -0.006 | 0.007 | 5019 | -0.88 | 0.997 |
| F0mean | T45 | -0.068 | -0.004 | 0.004 | 5019 | -1.09 | 0.985 |
| F0mean | T33 | 0.074 | 0.005 | 0.004 | 5019 | 1.18 | 0.975 |
| F0mean | T21 | 0.180 | 0.011 | 0.004 | 5019 | 2.87 | 0.114 |
| F0mean | T315 | 0.137 | 0.008 | 0.004 | 5019 | 2.19 | 0.467 |
| F0mean | T241 | -0.388 | -0.024 | 0.004 | 5019 | -6.19 | **<.001** |
| F0excursion | T45 | -0.045 | -0.006 | 0.008 | 5019 | -0.72 | 0.999 |
| F0excursion | T33 | -0.065 | -0.008 | 0.008 | 5019 | -1.04 | 0.989 |
| F0excursion | T21 | -0.159 | -0.02 | 0.008 | 5019 | -2.54 | 0.248 |
| F0excursion | T315 | 0.216 | 0.027 | 0.008 | 5019 | 3.44 | **0.021** |
| F0excursion | T241 | -0.047 | -0.006 | 0.008 | 5019 | -0.74 | 0.999 |
| F0maxloc | T45 | -0.041 | -0.008 | 0.012 | 5019 | -0.66 | 1.000 |
| F0maxloc | T33 | 0.652 | 0.128 | 0.012 | 5019 | 10.41 | **<.001** |
| F0maxloc | T21 | -0.071 | -0.014 | 0.012 | 5019 | -1.13 | 0.981 |
| F0maxloc | T315 | 1.107 | 0.217 | 0.012 | 5019 | 17.66 | **<.001** |
| F0maxloc | T241 | 0.361 | 0.071 | 0.012 | 5019 | 5.74 | **<.001** |

Table C.4 Multiple comparisons of imitations of Thai tone types across Mandarin and Vietnamese groups with Tukey adjustments. Only the results of comparisons between the same tone types are shown. Effect sizes are shown, using Cohen’s *d.* Significant findings (*p* <.05) are shown in bold.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Thai tones | *d* | Estimate | *SE* | *df* | *t* | *p* |
| Duration | T45 | -0.089 | -0.010 | 0.005 | 1369 | -2.01 | 0.590 |
| Duration | T33 | 0.025 | 0.003 | 0.005 | 1367 | 0.55 | 1.000 |
| Duration | T21 | -0.091 | -0.010 | 0.005 | 1370 | -2.05 | 0.566 |
| Duration | T315 | 0.121 | 0.014 | 0.005 | 1365 | 2.74 | 0.158 |
| Duration | T241 | 0.039 | 0.004 | 0.005 | 1373 | 0.87 | 0.997 |
| F0mean | T45 | 0.270 | 0.017 | 0.003 | 277 | 4.98 | **<.001** |
| F0mean | T33 | 0.203 | 0.013 | 0.003 | 276 | 3.75 | **0.008** |
| F0mean | T21 | -0.001 | 0.000 | 0.003 | 277 | -0.02 | 1.000 |
| F0mean | T315 | -0.010 | -0.001 | 0.003 | 276 | -0.18 | 1.000 |
| F0mean | T241 | -0.259 | -0.016 | 0.003 | 277 | -4.77 | **<.001** |
| F0excursion | T45 | 0.162 | 0.022 | 0.015 | 79 | 1.46 | 0.902 |
| F0excursion | T33 | 0.146 | 0.020 | 0.015 | 79 | 1.32 | 0.946 |
| F0excursion | T21 | 0.381 | 0.052 | 0.015 | 79 | 3.45 | **0.029** |
| F0excursion | T315 | -0.541 | -0.073 | 0.015 | 79 | -4.90 | **<.001** |
| F0excursion | T241 | 0.556 | 0.075 | 0.015 | 79 | 5.03 | **<.001** |
| F0maxloc | T45 | 0.141 | 0.028 | 0.016 | 105 | 1.75 | 0.762 |
| F0maxloc | T33 | 0.252 | 0.050 | 0.016 | 105 | 3.13 | 0.065 |
| F0maxloc | T21 | 0.073 | 0.015 | 0.016 | 105 | 0.91 | 0.996 |
| F0maxloc | T315 | -0.095 | -0.019 | 0.016 | 105 | -1.18 | 0.974 |
| F0maxloc | T241 | -0.122 | -0.024 | 0.016 | 105 | -1.52 | 0.883 |

# APPENDIX D. ENGLISH GLOSSES FOR WORDS/MORPHEMES USED.

Table D1. Thai syllables and the English glosses of each as meaningful morphemes in Thai.

|  |  |  |  |
| --- | --- | --- | --- |
| Syllables | Thai characters | Chao values | Meanings |
| maa | มา | 33 | Come |
|  | หม่า | 21 | (to) Brew (i.e., ferment) |
|  | ม่า | 241 | Grandmother (generic, both maternal and paternal) |
|  | ม้า | 45 | Horse |
|  | หมา | 315 | Dog |
| mii | มี | 33 | Have, (to) have, possess, own |
|  | หมี่ | 21 | rice noodles |
|  | มี่ | 241 | noisy |
|  | มี้ | 45 | mom (spoken; Chinese origin) |
|  | หมี | 315 | bear (n.) |

Table D2. Mandarin syllables and the English glosses of each as meaningful morphemes in Mandarin.

|  |  |  |  |
| --- | --- | --- | --- |
| Syllables | Chinese characters | Chao values | Meanings |
| ma | 妈 | 55 | mother |
|  | 麻 | 35 | hemp |
|  | 马 | 214 | horse |
|  | 骂 | 51 | scold |
| mi | 咪 | 55 | wink |
|  | 谜 | 35 | myth |
|  | 米 | 214 | rice |
|  | 蜜 | 51 | honey |

Table D3. Vietnamese syllables and the English glosses of each as meaningful morphemes in Vietnamese.

|  |  |  |  |
| --- | --- | --- | --- |
| Syllables | Vietnamese characters | Chao values | Meanings |
| ma | ma | 44 | ghost |
|  | má | 35 | mother |
|  | mà | 22 | but |
|  | mã | 415 | tomb |
|  | mả | 214 | horse |
|  | mạ | 21 | rise seeding |
| mi | mi | 44 | you (arrogant) |
|  | mí | 35 | bound morpheme in *mí mắt* eyelid |
|  | mì | 22 | Chinese noodles |
|  | mĩ | 415 | bound morpheme as in *mĩ quan* = beautiful looking |
|  | mỉ | 214 | bound morpheme as in *tỉ mỉ* = to be meticulous |
|  | mị | 21 | to flatter, or as bound morpheme in *mị dân* = demagogic |