*Table 1: Number of pant-hoots by each individual in the two contiguous Kasekela and Mitumba communities at Gombe National Park, Tanzania and one geographically distant Kanyawara community at Kibale National Park, Uganda.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **National Park** | **Community** | **Individual** | **Age at beginning (years)** | **Total pant-hoots** | **Pant-hoots with climax screams** | **Pant-hoots with buildups** |
| Gombe | Kasekela  (N = 128) | Fundi  (FND) | 16 | 11 | 11 | 6 |
| Faustino  (FO) | 26 | 20 | 19 | 12 |
| Fudge  (FU) | 19 | 33 | 33 | 27 |
| Sheldon  (SL) | 33 | 15 | 12 | 14 |
| Sampson  (SN) | 19 | 38 | 35 | 34 |
| Zeus  (ZS) | 22 | 11 | 8 | 7 |
| Mitumba  (N = 86) | Edgar  (EDG) | 27 | 45 | 41 | 24 |
| Fansi  (FAN) | 14 | 8 | 8 | 3 |
| Kocha  (KOC) | 15 | 16 | 16 | 12 |
| Lamba  (LAM) | 14 | 9 | 9 | 5 |
| Londo  (LON) | 15 | 8 | 8 | 6 |
| Kibale | Kanyawara  (N = 111) | Big Brown  (BB) | 44 | 8 | 8 | 6 |
| Eslom  (ES) | 15 | 18 | 18 | 10 |
| Kakama  (KK) | 25 | 21 | 21 | 20 |
| Makoku  (LK) | 28 | 14 | 14 | 14 |
| Twig  (PG) | 22 | 10 | 10 | 6 |
| Stout  (ST) | 55 | 14 | 14 | 11 |
| Lanjo  (TJ) | 15 | 26 | 26 | 9 |

*Table 2: Structural acoustic features manually measured using Praat v 6.1.15 that are used in this study. We also indicate which features were used in other studies of chimpanzee dialects. Categorical variables are marked with \*. Only numeric variables were used in the multivariate analyses including the PCAs and pDFAs since those techniques do not handle categorical variables.*

*\*\*Drumming related variables were not included in the multivariate analysis due to small sample sizes. However, descriptive plots are included in the supplementary materials.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Structural acoustic features used in this study*** | ***Part of the pant-hoot*** | ***Crockford et al. 2004*** | ***Mitani et al. 1999*** | ***Mitani et al. 1992*** |
| Duration of the call (from build-up to letdown phases) (s) | Entire call | No | No | No |
| Presence of introduction phase\* | Introduction | Yes | No | No |
| Presence of build-up phase\* | Build-up | Yes | No | No |
| Number of build-up exhalation components | Build-up | Yes | No | No |
| Number of build-up components in the first half of the build-up | Build-up | Yes | No | No |
| Number of build-up components in the second half of the build-up | Build-up | Yes | No | No |
| Duration of build-up phase (s) | Build-up | Yes | Yes | No |
| Rate of build-up phase (components/s) | Build-up | Yes | Yes | Yes |
| Rate of first half of build-up phase (components/s) | Build-up | Yes | No | No |
| Rate of second half of build-up phase (components/s) | Build-up | Yes | No | No |
| Build-up acceleration (rate of second half - rate of first half) | Build-up | Yes | No | No |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Structural acoustic features used in this study*** | ***Part of the pant-hoot*** | ***Crockford et al. 2004*** | ***Mitani et al. 1999*** | ***Mitani et al. 1992*** |
| Presence of climax phase\* | Climax | Yes | No | No |
| Total number of climax elements (including screams and non-scream components) | Climax | Yes | No | No |
| Number of screams in climax | Climax | Yes | No | No |
| Proportion of climax components that are screams | Climax | Yes | No | No |
| Duration of climax phase (s) | Climax | No | No | No |
| Presence of letdown phase\* | Letdown | Yes | No | No |
| Number of components in letdown phase | Letdown | Yes | No | No |
| ***Structural acoustic feature(s) NOT  used in this study*** | | | | |
| Number of introduction components | Introduction | Yes | No | No |
| Duration of introduction component | Introduction | No | Yes | No |
| Drumming related features\*\* | Drumming | Yes | No | No |

*Table 3: Semi-automatically measured acoustic features using LMA from the selected build-up and climax components compared with other studies. Some acoustic features were not used in this study as they were not measured by the version of LMA available to us.*

|  |  |  |  |
| --- | --- | --- | --- |
| ***Acoustic feature(s) used in this study*** | ***Crockford et al. 2004*** | ***Mitani et al. 1999*** | ***Mitani et al. 1992*** |
| Duration of the component (ms) | No (for build-up);  Yes (for climax) | Yes | Yes |
| Start, end, maximum, minimum, and mean fundamental frequency F0 (Hz) | No (for build-up);  Yes (for climax) | No (start and end);  Yes (maximum, minimum, and mean) | No |
| Frequency range of F0 (Maximum F0 - Minimum F0) (Hz) | No | Yes | Yes |
| Tonality measures: mean and maximum frequency difference between the original F0 curve and the floating average curve (Hz) | No (for build-up);  Yes (for climax) | No | No |
| Location of maximum F0 relative to the duration ([1/duration]\*location) | No (for build-up);  Yes (for climax) | No | No |
| Factor of linear trend of F0 (measures if the F0 is rising, falling, or flat on average) | No (for build-up);  Yes (for climax) | No | No |
| Mean and maximum deviations between F0 and linear trend line (Hz) | No (for build-up);  Yes (for climax) | No | No |
| Start, end, maximum, minimum, and mean peak frequencies (Hz) | No (for build-up);  Yes (for climax) | No | No |
| Peak frequencies with maximum and minimum amplitude (Hz) | No (for build-up);  Yes (for climax) | No | No |
| Locations of maximum and minimum peak frequencies relative to the duration ([1/duration]\*location) | No | No | No |
| Maximum difference between peak frequency values in successive time segments (Hz) | No (for build-up);  Yes (for climax) | No | No |
| Mean and maximum wiener entropy coefficient (0-1; 1=noise) | No | No | No |
| ***Acoustic feature(s) NOT  used in this study*** | | | |
| Slope of F0 from start to maximum (Hz/ms) | Yes | No | No |
| Slope of peak frequency from start to maximum (Hz/ms) | Yes | No | No |
| Maximum F0 start F0 (Hz) and Maximum F0 minimum F0 (Hz) | Yes | No | No |
| F0 at midpoint of introduction element (Hz) | Yes | Yes | No |
| Peak frequency at midpoint of inhaled elements (Hz) | Yes | No | No |
| Peak frequency at midpoint of exhaled elements (Hz) | Yes | No | No |
| Peak frequency of inhaled - peak frequency of exhaled elements (Hz) | Yes | No | No |
| Ratio of F1/F2, the first and second formant frequencies | No | Yes | No |
| Bandwidth (Hz) | No | Yes | No |

*Table 4: Summary of the results from the pDFAs on the structural acoustic features. We indicate the test factor and the control factor used in the pDFAs, number of individuals included in the analyses, the range of number of calls per individual and the total number of calls considered for each of the analyses. The observed cross-validated classification accuracy on the original dataset is compared with the expected value of the classification accuracy obtained from the distribution of classification accuracies obtained from the 1000 permutations. This is used to calculate the p-value. Significant differences are indicated with \*.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Test factor*** | ***Control factor*** | ***Number***  ***of individuals included*** | ***Range of calls per individual***  ***(Median)*** | ***Total number of calls used*** | ***Observed cross-validated classification accuracy***  ***(Expected value)*** | ***P-value for cross-validated classification accuracy*** |
| Context | Individual | 11 | Feed: 3-25 (7)  Travel: 3-12 (6) | 183 | 63.9 (51.7) | 0.044\* |
| Individual | Context | 7 | 9-34 (14) | 119 | 36.7 (24.8) | 0.043\* |
| Community | Context | Kasekela: 6  Mitumba: 3  Kanyawara: 7 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7)  Kanyawara: 8-26 (14) | 212 | 43.3 (40.8) | 0.322 |
| Community | Individual | Kasekela: 6  Mitumba: 3  Kanyawara: 7 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7)  Kanyawara: 8-26 (14) | 212 | 35.4 (39.7) | 0.729 |
| Community  (contiguous) | Context | Kasekela: 6  Mitumba: 3 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7) | 103 | 61.4 (58.3) | 0.412 |
| Community  (contiguous) | Individual | Kasekela: 6  Mitumba: 3 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7) | 103 | 53 (56) | 0.639 |

*Table 5: Summary of the results from the pDFAs with context as the test factor and individual identity as the control factor. We indicate the number of individuals recorded in both feeding and traveling contexts, the range of number of calls per individual and the total number of calls considered for each of the analyses. The observed cross-validated classification accuracy on the original dataset is compared with the expected value of the classification accuracy obtained from the distribution of classification accuracies obtained from the 1000 permutations. This is used to calculate the p-value.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Acoustic features used*** | ***Control factor*** | ***Number of individuals included in both contexts*** | ***Range of calls per individual in each context***  ***(Median)*** | ***Total number of calls used*** | ***Observed cross-validated classification accuracy***  ***(Expected value)*** | ***P-value for cross-validated classification accuracy*** |
| Structural  (Table 2) | Individual | 11 | Feed: 3-25 (7)  Travel: 3-12 (6) | 183 | 63.9 (51.7) | 0.044\* |
| Build-up  (Table 3) | Individual | 9 | Feed: 3-20 (6)  Travel: 3-12 (6) | 121 | 51.9 (49.6) | 0.376 |
| Climax  (Table 3) | Individual | 12 | Feed: 3-26 (7.5)  Travel: 3-12 (6.5) | 203 | 52.2 (50.2) | 0.34 |
| Entire call  (Table 2 and 3) | Individual | 6 | Feed: 3-9 (6)  Travel: 3-12 (6.5) | 77 | 50.8 (47.7) | 0.37 |

*Table 6: Summary of the results from the pDFAs with community identity as the test factor and individual identity as the control factor. We indicate the number of individuals from each community, the range of number of calls per individual and the total number of calls considered for each of the analyses. The observed cross-validated classification accuracy on the original dataset is compared with the expected value of the classification accuracy obtained from the distribution of classification accuracies obtained from the 1000 permutations. This is used to calculate the p-value.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Acoustic features used*** | ***Control factor*** | ***Number of individuals included per community*** | ***Range of calls per individual in each community (Median)*** | ***Total number of calls used*** | ***Observed cross-validated classification accuracy***  ***(Expected value)*** | ***P-value for cross-validated classification accuracy*** |
| *All communities* | | | | | | |
| Structural  (Table 2) | Individual | Kasekela: 6  Mitumba: 3  Kanyawara: 7 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7)  Kanyawara: 8-26 (14) | 212 | 35.4 (39.7) | 0.729 |
| Structural  (Table 2) | Context | Kasekela: 6  Mitumba: 3  Kanyawara: 7 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7)  Kanyawara: 8-26 (14) | 212 | 43.3 (40.8) | 0.322 |
| Build-up  (Table 3) | Individual | Kasekela: 6  Mitumba: 4  Kanyawara: 7 | Kasekela: 6-33 (13)  Mitumba: 5-24 (9)  Kanyawara: 6-20 (10) | 222 | 45 (37.6) | 0.08 |
| Climax  (Table 3) | Individual | Kasekela: 6  Mitumba: 5  Kanyawara: 7 | Kasekela: 8-34 (15.5)  Mitumba: 8-41 (9)  Kanyawara: 8-26 (14) | 310 | 54.0 (40.8) | 0.016\* |
| Entire call  (Table 2 and 3) | Individual | Kasekela: 5  Mitumba: 5  Kanyawara: 7 | Kasekela: 6-28 (11)  Mitumba: 3-19 (5)  Kanyawara: 6-20 (10) | 191 | 51.3 (42.2) | 0.079 |
| *Communities from Gombe* | | | | | | |
| Structural  (Table 2) | Individual | Kasekela: 6  Mitumba: 3 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7) | 103 | 53 (56) | 0.639 |
| Structural  (Table 2) | Context | Kasekela: 6  Mitumba: 3 | Kasekela: 4-21 (8)  Mitumba: 4-34 (7) | 103 | 61.4 (58.3) | 0.412 |
| Build-up  (Table 3) | Individual | Kasekela: 6  Mitumba: 4 | Kasekela: 6-33 (13)  Mitumba: 5-24 (9) | 146 | 58.5 (53.5) | 0.255 |
| Climax  (Table 3) | Individual | Kasekela: 6  Mitumba: 5 | Kasekela: 8-34 (15.5)  Mitumba: 8-41 (9) | 199 | 70.7 (58) | 0.089 |
| Entire call  (Table 2 and 3) | Individual | Kasekela: 5  Mitumba: 5 | Kasekela: 6-28 (11)  Mitumba: 3-19 (5) | 115 | 59.6 (54.6) | 0.272 |

*Table 7: Summary of the results from the pDFAs with individual identity as the test factor and community as the restriction factor. We indicate the number of individuals from each community, the range of number of calls per individual and the total number of calls considered for each of the analyses. The observed cross-validated classification accuracy on the original dataset is compared with the expected value of the classification accuracy obtained from the distribution of classification accuracies obtained from the 1000 permutations. This is used to calculate the p-value.*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***Acoustic features used*** | ***Control or restriction factor*** | ***Number of individuals included*** | ***Range of calls per individual (Median)*** | ***Total number of calls used*** | ***Observed cross-validated classification accuracy***  ***(Expected value)*** | ***P-value for cross-validated classification accuracy*** |
| *All communities* | | | | | | |
| Structural  (Table 2) | Community (restriction factor) | 18 | 4-41 (13.5) | 280 | 19.5 (6.9) | 0.001\* |
| Structural  (Table 2) | Context  (control factor) | 7 | 9-34 (14) | 119 | 35.8 (24.7) | 0.043\* |
| Build-up (Table 3) | Community (restriction factor) | 17 | 5-33 (11) | 222 | 10.6 (8.2) | 0.18 |
| Climax  (Table 3) | Community (restriction factor) | 18 | 8-41 (14) | 310 | 20.1 (9.4) | 0.001\* |
| Entire call (Table 2 and 3) | Community (restriction factor) | 17 | 3-28 (10) | 191 | 14.4 (7.6) | 0.007\* |
| *Communities from Gombe* | | | | | | |
| Structural  (Table 2) | Community (restriction factor) | 11 | 4-41 (13) | 171 | 24 (10.3) | 0.001\* |
| Structural  (Table 2) | Context  (control factor) | Not performed due to low sample sizes of individuals recorded in both contexts | | | | |
| Build-up (Table 3) | Community (restriction factor) | 10 | 5-33 (12) | 146 | 16.1 (12.1) | 0.15 |
| Climax  (Table 3) | Community (restriction factor) | 11 | 8-41 (12) | 199 | 24.2 (13.2) | 0.006\* |
| Entire call (Table 2 and 3) | Community (restriction factor) | 10 | 3-28 (10) | 115 | 23.5 (13.2) | 0.024\* |

*Figure 1: A spectrogram of a typical pant-hoot call with the four phases and drumming labelled.*

Diagram

Description automatically generated

*Figure 2: Principal Components Analysis on structural features. (a) Shows 68% normal data ellipses of different contexts overlayed on the PCA, (b) Shows 68% normal data ellipses of different communities overlayed on the PCA, and (c) Shows 68% normal data ellipses of different individuals with at least 4 recordings in each context overlayed on the PCA.*



*Figure 3: Principal Components Analysis on (a) acoustic features of the selected build-up component, (b) acoustic features of the selected climax component, and (c) the structural features as well as features of the selected build-up and climax components from all three communities. The 68% normal data ellipses containing 68% of the data points are included for each context. The strong overlap suggests no differences between contexts.*



## *Figure 4: Principal Components Analysis on (a) acoustic features of the selected build-up component. (b) Acoustic features of the selected climax component. Kasekela and geographically distant Kanyawara communities separate to some extent over PC2. (c) The structural features as well as features of the selected build-up and climax components from all three communities. The 68% normal data ellipses containing 68% of the data points are included for each community. The strong overlap overall suggests no differences among communities.*



*Figure 5: Principal Components Analysis on the structural features as well as features of the selected build-up and climax elements from the three communities. The 68% normal data ellipses reveal a lower overlap compared to community identity and context. Plot for (a) Kasekala. Some individuals form distinct clusters over PC2. (b) Mitumba. Some individuals form distinct clusters over a combination of PC1 and PC2. (c) Kanyawara. Some individuals form distinct clusters over PC2 and others over PC1.*

