

Dance Entropy Analysis

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Entropy has been calculated using MatLab code for 176 biomechanical variables measured through the Noraxon system during dance sessions in participants with Parkinson's Disease (PD) and control older adults (OA). This document outlines the statistical results.

Data Cleaning

Data was cleaned using the following criteria:

- Date was extracted from filename and added to new Date column
- Participant ID extracted from filename and added to new Participant column
- Dance Type was extracted from filename and added to new Dance Type column
- Rumba, Swing, Electric Slide data were removed
- New Group column was created where data was organized into "OA" or "PD"
- All values equal to "0" were replaced with "NA". 0 indicates a failure of the biomechanical sensors and thus are excluded from analysis
- One observation of Tango was removed as there were NA data for any of the variables.

The cleaned data were saved as df_clean.

df_clean was further separated into PD or OA data, for ease of analysis. These are shown below.

df_pd

```
## # A tibble: 19 x 14
##   Date                Participant Dance_Type `SamEn_Elbow-LT~
##   <dtm>              <fct>      <fct>      <dbl>
## 1 2018-07-14 12:20:00 pddance001 Tango        0.000623
## 2 2018-07-14 12:32:00 pddance001 Tango        0.000273
## 3 2018-08-11 11:55:00 pddance002 Line Dance    0.00709
## 4 2018-08-11 12:03:00 pddance002 Foxtrot       0.0530
## 5 2018-08-11 12:08:00 pddance002 Foxtrot       0.0587
## 6 2018-08-11 12:13:00 pddance002 Waltz         0.0434
## 7 2018-08-11 12:19:00 pddance002 Tango         0.0317
```

```
## 8 2018-08-11 12:20:00 pddance002 Tango 0.0334
## 9 2018-08-11 12:30:00 pddance002 Tango 0.0105
## 10 2018-10-13 12:11:00 pddance003 Tango 0.0107
## 11 2018-10-13 12:26:00 pddance003 Tango 0.00177
## 12 2018-11-10 12:28:00 pddance005 Tango 0.0164
## 13 2018-11-10 12:34:00 pddance005 Tango 0.00113
## 14 2018-12-08 12:07:00 pddance005 Foxtrot 0.0336
## 15 2018-12-08 12:15:00 pddance005 Foxtrot 0.0929
## 16 2018-12-08 12:19:00 pddance005 Tango 0.0334
## 17 2018-12-08 12:30:00 pddance005 Tango NA
## 18 2019-09-14 12:14:00 pddance007 Tango 0.00209
## 19 2019-09-14 12:21:00 pddance007 Tango 0.000611
## # ... with 10 more variables: `SamEn_Elbow-RT-Flexion (deg)` <dbl>,
## # `SamEn_Hip-LT-Abduction (deg)` <dbl>, `SamEn_Hip-LT-Flexion
## # (deg)` <dbl>, `SamEn_Hip-LT-Rotation Ext (deg)` <dbl>,
## # `SamEn_Hip-RT-Abduction (deg)` <dbl>, `SamEn_Hip-RT-Flexion
## # (deg)` <dbl>, `SamEn_Hip-RT-Rotation Ext (deg)` <dbl>,
## # `SamEn_Knee-LT-Flexion (deg)` <dbl>, `SamEn_Knee-RT-Flexion
## # (deg)` <dbl>, Group <fct>
```

```
df_oa
```

```
## # A tibble: 10 x 14
##   Date          Participant Dance_Type `SamEn_Elbow-LT~
##   <dtm>          <fct>         <fct>         <dbl>
## 1 2018-10-11 13:38:00 pddancecon- Line Dance 0.0562
## 2 2018-10-11 13:53:00 pddancecon- Waltz 0.000248
## 3 2018-10-11 14:44:00 pddancecon- Waltz 0.0647
## 4 2018-10-11 14:57:00 pddancecon- Waltz 0.00180
## 5 2018-10-18 13:41:00 pddancecon- Foxtrot 0.00407
## 6 2018-10-18 13:50:00 pddancecon- Foxtrot 0.00942
## 7 2018-10-18 14:03:00 pddancecon- Tango 0.00398
## 8 2018-10-18 14:39:00 pddancecon- Tango 0.00268
## 9 2018-10-18 14:51:00 pddancecon- Tango NA
## 10 2018-10-18 14:58:00 pddancecon- Tango 0.00309
## # ... with 10 more variables: `SamEn_Elbow-RT-Flexion (deg)` <dbl>,
## # `SamEn_Hip-LT-Abduction (deg)` <dbl>, `SamEn_Hip-LT-Flexion
## # (deg)` <dbl>, `SamEn_Hip-LT-Rotation Ext (deg)` <dbl>,
## # `SamEn_Hip-RT-Abduction (deg)` <dbl>, `SamEn_Hip-RT-Flexion
## # (deg)` <dbl>, `SamEn_Hip-RT-Rotation Ext (deg)` <dbl>,
## # `SamEn_Knee-LT-Flexion (deg)` <dbl>, `SamEn_Knee-RT-Flexion
## # (deg)` <dbl>, Group <fct>
```

Data Statistics

Descriptive Statistics

```
##
## Attaching package: 'kableExtra'

## The following object is masked from 'package:dplyr':
##
##   group_rows
```

```
##
## Attaching package: 'xtable'

## The following object is masked from 'package:formattable':
##
##     digits

## # A tibble: 29 x 14
##   Date                Participant Dance_Type `SamEn_Elbow-LT~
##   <dtm>              <fct>         <fct>         <dbl>
## 1 2018-07-14 12:20:00 pddance001   Tango           0.000623
## 2 2018-07-14 12:32:00 pddance001   Tango           0.000273
## 3 2018-08-11 11:55:00 pddance002   Line Dance      0.00709
## 4 2018-08-11 12:03:00 pddance002   Foxtrot         0.0530
## 5 2018-08-11 12:08:00 pddance002   Foxtrot         0.0587
## 6 2018-08-11 12:13:00 pddance002   Waltz           0.0434
## 7 2018-08-11 12:19:00 pddance002   Tango           0.0317
## 8 2018-08-11 12:20:00 pddance002   Tango           0.0334
## 9 2018-08-11 12:30:00 pddance002   Tango           0.0105
## 10 2018-10-11 13:38:00 pddancecon~ Line Dance      0.0562
## # ... with 19 more rows, and 10 more variables: `SamEn_Elbow-RT-Flexion
## #   (deg)` <dbl>, `SamEn_Hip-LT-Abduction (deg)` <dbl>,
## #   `SamEn_Hip-LT-Flexion (deg)` <dbl>, `SamEn_Hip-LT-Rotation Ext
## #   (deg)` <dbl>, `SamEn_Hip-RT-Abduction (deg)` <dbl>,
## #   `SamEn_Hip-RT-Flexion (deg)` <dbl>, `SamEn_Hip-RT-Rotation Ext
## #   (deg)` <dbl>, `SamEn_Knee-LT-Flexion (deg)` <dbl>,
## #   `SamEn_Knee-RT-Flexion (deg)` <dbl>, Group <fct>

## `mutate_if()` ignored the following grouping variables:
## Column `Group`

## Adding missing grouping variables: `Group`

## % latex table generated in R 3.6.1 by xtable 1.8-4 package
## % Sun Nov 03 01:21:40 2019
## \begin{table}[ht]
## \centering
## \begin{tabular}{lrrrrr}
## \hline
## & Df & Sum Sq & Mean Sq & F value & Pr(>F) \\
## \hline
## Dance\_Type & 3 & 0.00 & 0.00 & 3.05 & 0.0489 \\
## Residuals & 23 & 0.01 & 0.00 & & \\
## \hline
## \end{tabular}
## \end{table}
```

Difference between sides, within dances

The plots below demonstrate that for PD participants Foxtrot had the greatest mean SamEn of both left elbow flexion and left knee flexion, reenforcing our findings from the TukeyHSD run above.

PD participants also tended to show greater mean right hip abduction SamEn when compared to OA participants.

Table 1: Mean SamEn of Variables per Dance

Group	Dance_Type	Left Side					Right Side				
		Elbow-LT-Flexion	Hip-LT-Abduction	Hip-LT-Flexion	Hip-LT-Rotation Ext	Knee-LT-Flexion	Elbow-RT-Flexion	Hip-RT-Abduction	Hip-RT-Flexion	Hip-RT-Rotation Ext	Knee-RT-Flexion
Older Adults Group											
OA	Foxtrot	0.007	0.078	0.052	0.041	0.027	0.021	0.001	0.055	0.072	0.027
OA	Line Dance	0.056	0.097	0.014	0.025	0.015	0.007	0.002	0.020	0.089	0.018
OA	Tango	0.003	0.044	0.028	0.031	0.034	0.017	0.002	0.010	0.068	0.036
OA	Waltz	0.022	0.079	0.038	0.107	0.059	0.023	0.000	0.039	0.070	0.033
Parkinson's Disease Group											
PD	Foxtrot	0.060	0.112	0.069	0.027	0.088	0.046	0.063	0.081	0.065	0.026
PD	Line Dance	0.007	0.095	0.088	0.031	0.117	0.020	0.191	0.059	0.099	0.016
PD	Tango	0.012	0.091	0.051	0.021	0.042	0.042	0.022	0.046	0.072	0.033
PD	Waltz	0.043	0.127	0.157	0.037	0.071	0.045	0.128	0.057	0.045	0.027

Note:

OA group was all female, PD group was all male.

PD left v right side

Is there a significant difference in left vs right SamEn, per Dance_Type?

H0: left_variable = right_variable

HA: left_variable > right_variable

p values	Elbow Flexion	Hip Abduction	Hip Rotation	Hip Flexion	Elbow Flexion
Tango	0.02333	0.00000046	0.000096	0.71698	0.47055
Foxtrot	0.52267	0.02530	0.08354	0.56562	0.00612

PD Line and Waltz did not have enough data for a t test.

PD Plot

```
## Warning: Ignoring unknown aesthetics: xmin, xmax, annotations, y_position
```

```
## Warning: Removed 9 rows containing missing values (geom_point).
```



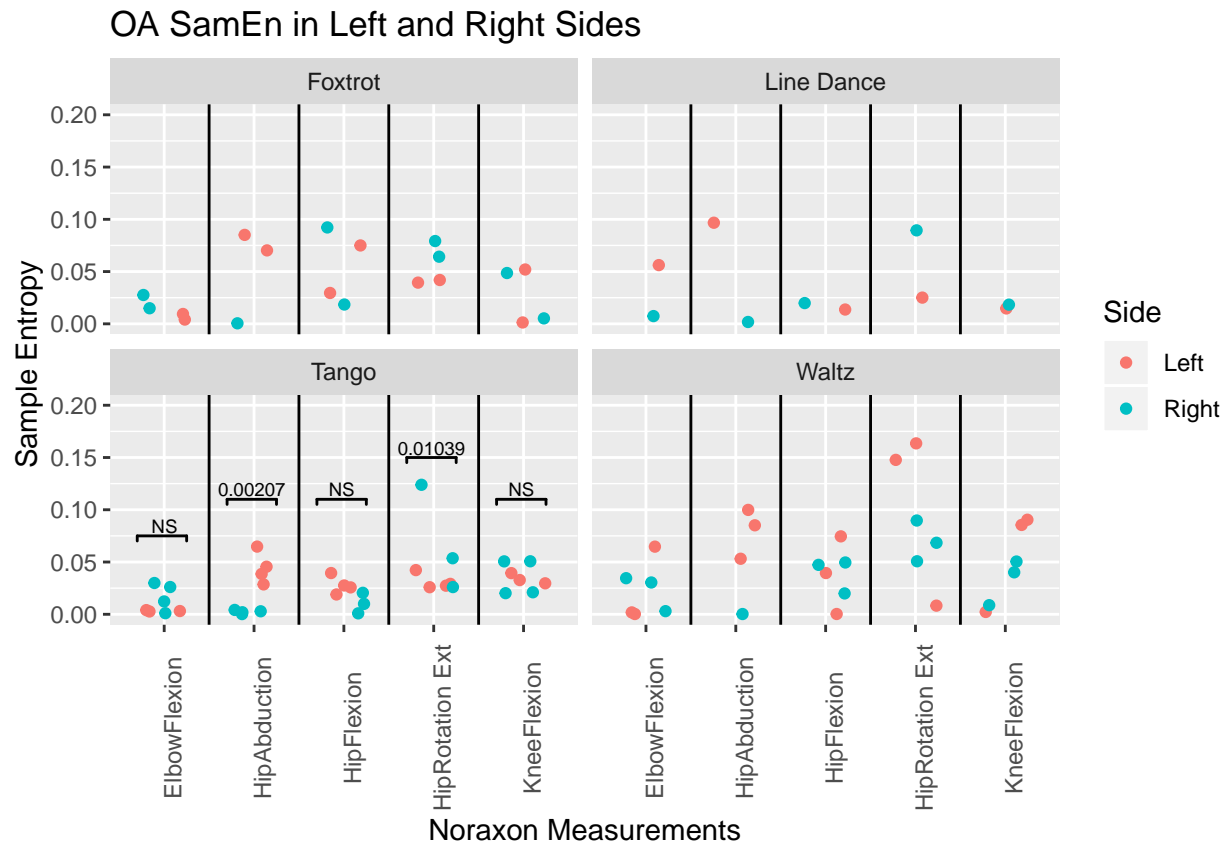
p values	Elbow Flexion	Hip Abduction	Hip Rotation	Hip Flexion	Elbow Flexion
Tango	0.29891	0.00207	0.20024	0.01039	0.89776

OA Foxtrot, Line and Waltz did not have enough data for a t test.

OA Plot

```
## Warning: Ignoring unknown aesthetics: xmin, xmax, annotations, y_position
```

```
## Warning: Removed 7 rows containing missing values (geom_point).
```



Difference amongst dances

A MANOVA was run to determine whether any significant differences exist between dance types in terms of the 10 variables. This turned out to be significant ($p < 0.001$).

```
##               Df Pillai approx F num Df den Df   Pr(>F)
## df_pd$Dance_Type 3 2.5543   4.0111   30    21 0.000796 ***
## Residuals       14
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The dependent variables significantly different between dances include:

- SamEn_Elbow-LT-Flexion ($p < 0.01$)
- SamEn_Hip-RT-Abduction ($p < 0.01$)
- SamEn_Knee-LT-Flexion was slightly significant ($p < 0.1$)

The following only shows the significant results:

```
## [1] "SamEn_Elbow-LT-Flexion"

##              Df  Sum Sq  Mean Sq F value  Pr(>F)
## df_pd$Dance_Type  3 0.007473 0.0024911    8.999 0.00142 **
## Residuals        14 0.003875 0.0002768
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness

## [1] "SamEn_Hip-RT-Abduction"

##              Df  Sum Sq  Mean Sq F value  Pr(>F)
## df_pd$Dance_Type  3 0.03579 0.011932    7.924 0.00248 **
## Residuals        14 0.02108 0.001506
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness

## [1] "SamEn_Knee-LT-Flexion"

##              Df  Sum Sq  Mean Sq F value  Pr(>F)
## df_pd$Dance_Type  3 0.01017 0.003390    2.54 0.0984 .
## Residuals        14 0.01869 0.001335
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 1 observation deleted due to missingness
```

TukeyHSD was run to determine which dances saw the significant difference in the appropriate SamEn.

- SamEn in LT elbow flexion was significantly different between TANGO and FOXTROT ($p = 0.001$)
- SamEn in RT hip abduction was significantly different between TANGO and LINE DANCE ($p = 0.005$), LINE DANCE and FOXTROT ($p = 0.046$)
- SamEn in LT knee flexion was NOT significantly different between any dances ($p > 0.1$ for all comparisons)

```
## [1] "SamEn_Elbow-LT-Flexion"

## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = df_pd$`SamEn_Elbow-LT-Flexion (deg)` ~ df_pd$Dance_Type)
##
## $`df_pd$Dance_Type`
##              diff          lwr          upr          p adj
## Line Dance-Foxtrot -0.052456068 -0.10652326  0.00161112 0.0585584
```

```

## Tango-Foxtrot      -0.047649271 -0.07556945 -0.01972910 0.0010620
## Waltz-Foxtrot      -0.016172970 -0.07024016 0.03789422 0.8203587
## Tango-Line Dance   0.004806797 -0.04552702 0.05514061 0.9921926
## Waltz-Line Dance   0.036283098 -0.03210709 0.10467328 0.4404207
## Waltz-Tango        0.031476301 -0.01885751 0.08181011 0.3061002

## [1] "SamEn_Hip-RT-Abduction"

## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = df_pd$`SamEn_Hip-RT-Abduction (deg)` ~ df_pd$Dance_Type)
##
## $`df_pd$Dance_Type`
##              diff              lwr              upr              p adj
## Line Dance-Foxtrot 0.12788073 0.001780399 0.25398105 0.0463709
## Tango-Foxtrot      -0.04109173 -0.106209664 0.02402619 0.2990083
## Waltz-Foxtrot      0.06476230 -0.061338026 0.19086263 0.4672658
## Tango-Line Dance   -0.16897246 -0.286365478 -0.05157945 0.0045028
## Waltz-Line Dance   -0.06311842 -0.222624125 0.09638727 0.6660919
## Waltz-Tango        0.10585404 -0.011538980 0.22324705 0.0836766

## [1] "SamEn_Knee-LT-Flexion"

## Tukey multiple comparisons of means
## 95% family-wise confidence level
##
## Fit: aov(formula = df_pd$`SamEn_Knee-LT-Flexion (deg)` ~ df_pd$Dance_Type)
##
## $`df_pd$Dance_Type`
##              diff              lwr              upr              p adj
## Line Dance-Foxtrot 0.02920514 -0.08951820 0.14792848 0.8894975
## Tango-Foxtrot      -0.04554455 -0.10685302 0.01576391 0.1826610
## Waltz-Foxtrot      -0.01703513 -0.13575847 0.10168821 0.9746386
## Tango-Line Dance   -0.07474969 -0.18527511 0.03577572 0.2466320
## Waltz-Line Dance   -0.04624027 -0.19641474 0.10393419 0.8075873
## Waltz-Tango        0.02850942 -0.08201599 0.13903483 0.8752778

```