Generalized Synchronization by Rhythmic Stimuli in Football

or

How to orchestrate a football team?

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Introduction:

25 pass goal as an example of joint action


Emirates
HYUNDAI
McDonald's
MasterCard

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This is a kind of nonverbal communication!

Introduction:

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How do the players manage to synchronize in a generalized sense?

How one can promote the appearance of such collective dynamics?

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4. **Coupled nonlinear oscillators may show generalized synchronization (Rulkov, 1995), viz. they may not doing the same but the response of one unit is a function of the other and vice versa. At a given coupling, the probability for the occurrence of generalized increases if the dominant Fourier frequencies of the oscillators get more similar**

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Is it possible to increase the degree of generalized synchronization (viz. the quality of the interplay) of a football team by an adequate acoustic stimulus?

Design of the experiment:

Small Field (32m by 40m)
5 against 5 randomly experienced(!) chosen players
Two small goals on each side to provoke passing

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Players were equipped with receivers to pick up either synchr. or nonsynchr. stimuli

team-classification was randomized,
each match in 3 thirds of 10 min,

- without music,
- A synchr. B nonsynchr.,
- visa versa

Hypothesis:

The teams perform better in the synchronous setting

Scheme of the statistical Analysis:

Data acquisition via eye revision of the video recordings

1. number of ball contacts
2. number of passes
3. number of pass-chains

Game	10	
Condition	1	–1
Goals	3	2
Pass–chains	16	14

Team A		Team B	
Passes	Contacts	Passes	Contacts
3	13	4	13
3	14	3	9
1	4	4	8
1	3	4	10
6	22	5	15
•		•	
•		•	
•		•	

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En total we performed 18 matches each divided by three thirds realizing the three settings in a random order.

Scheme of the statistical Analysis:

$$Collectivity = \frac{\#\,passes}{\#\,contacts}$$

RESULTS:
according the non-parametric Mann-Whitney-Wilcoxon-rank test:

without Music – Sync	without Music – Async	Sync – Async
11.8%	3.8%	0.6%

Scheme of the statistical Analysis:

$$Collectivity = \frac{\#\,passes}{\#\,contacts}$$

Pair-statistics: we should not measure the performance of a particular team against another one, but the performance of a particular team under different conditions:

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$$S_A = \frac{C_A^{Sy}}{C_B^{As}} - \frac{C_A^{As}}{C_B^{Sy}}$$

Representation of the null-hypothesis:

(1) Take randomly two pass-chains numbers Np1 and Np2 from the pool of measurements **without acoustic stimulus**

Pass–chains

Game	Team A	Team B
1	14	14
2	17	15
3	13	13
4	19	15
5	20	14
6	16	20
7	18	19
8	16	17
9	18	19

np1=14

np2=19

Representation of the null-hypothesis:

(1) Take randomly two pass-chains numbers Np1 and Np2 from the pool of measurements **without acoustic stimulus**

(2) From the same pool take Np1 and Np2 pairs of number of passes and number of contacts

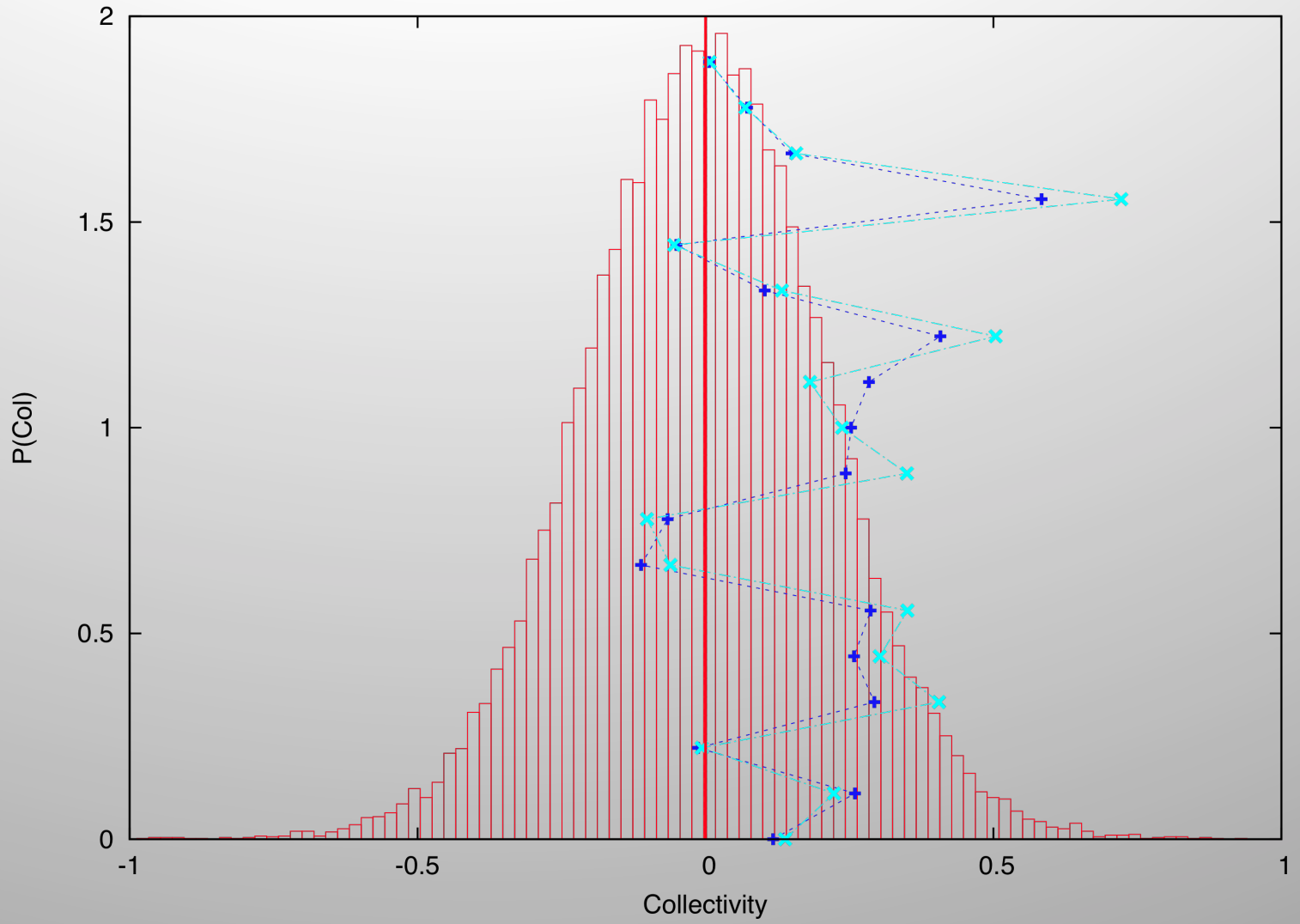
Numbers taken from real games

Team A		Team B	
Passes	Contacts	Passes	Contacts
6	21	7	11
3	12	5	9
0	2	0	5
1	3	4	15
11	29	2	5
3	16	9	21
0	4	3	14
10	28	5	13
4	13	9	18

Fictitious game

Team A		Team B	
14 chains		19 chains	
Passes	Contacts	Passes	Contacts
0	2	7	11
6	21	2	5
3	16	4	13
	⋮		

Results:



Significance: MWWr-test

Team A 0.046 %

Team B 0.03 %

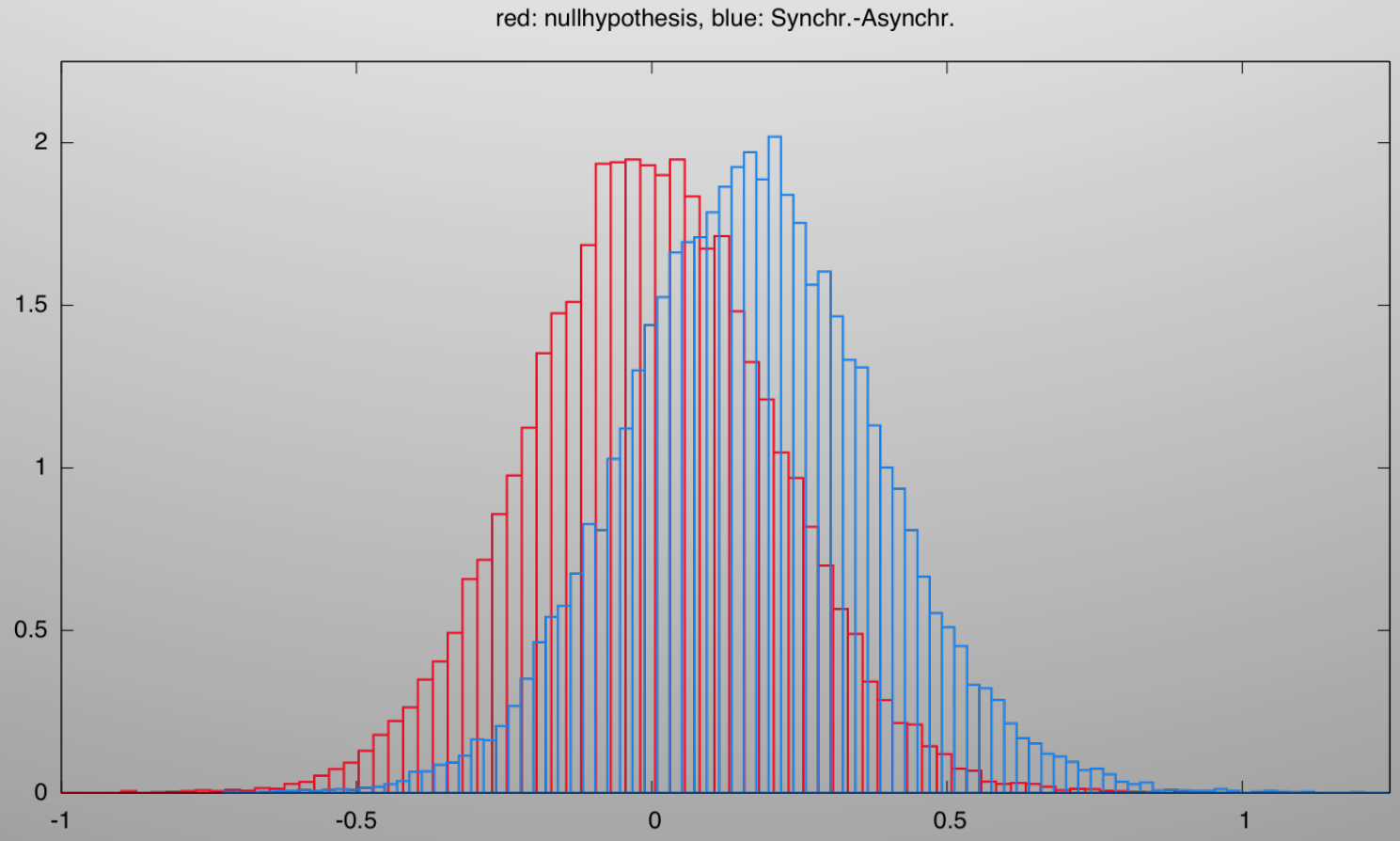
Significance of goal-difference is about 10%

An alternative strategy:

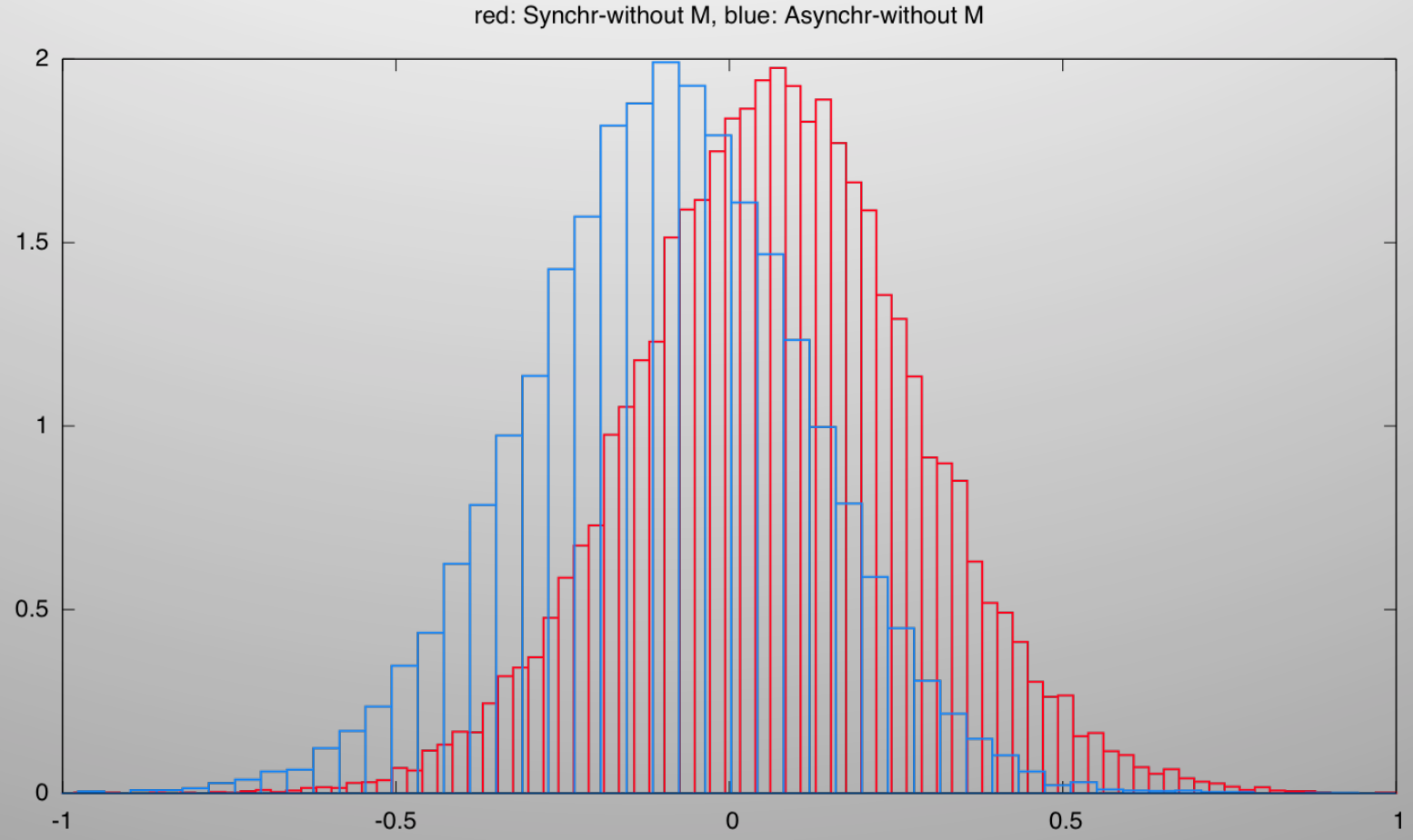
We can also create ensembles of random numbers of the pair statistic derived from the data pool of the synchronous and asynchronous setting!

Nulll hypothesis (red) against synchron-asynchron condition (blue) but now the collectivity values are random numbers

$$S_A = \frac{C_A^{Sy}}{C_B^{As}} - \frac{C_A^{As}}{C_B^{Sy}}$$



$$S_A = \frac{C_A^{As}}{C_B^{wM}} - \frac{C_A^{wM}}{C_B^{As}} \qquad S_A = \frac{C_A^{Sy}}{C_B^{wM}} - \frac{C_A^{wM}}{C_B^{Sy}}$$



$< S >= -0.098 \pm 0.21$ $< S >= 0.072 \pm 0.21$

What about more classical indicators like goals and number of passes?

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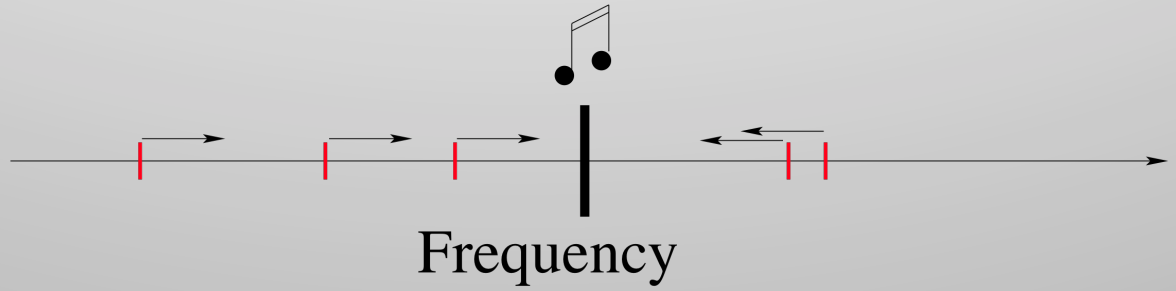
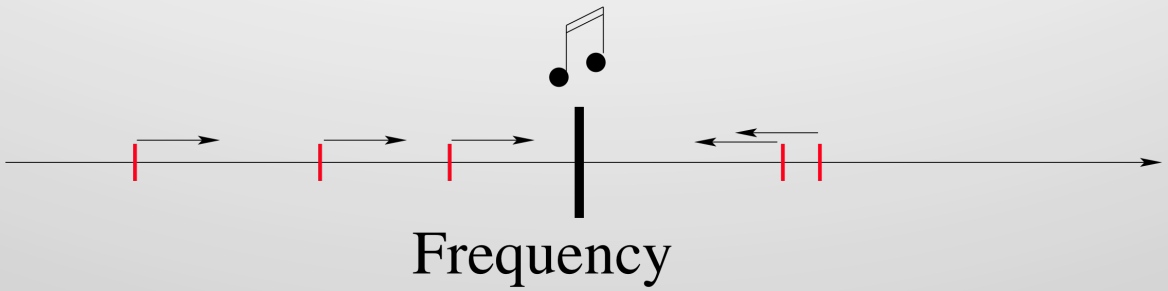
	without Stimulus	Synchron	Asynchron
Goals	120	140	114
Passes	2105	2176	2019


Frequency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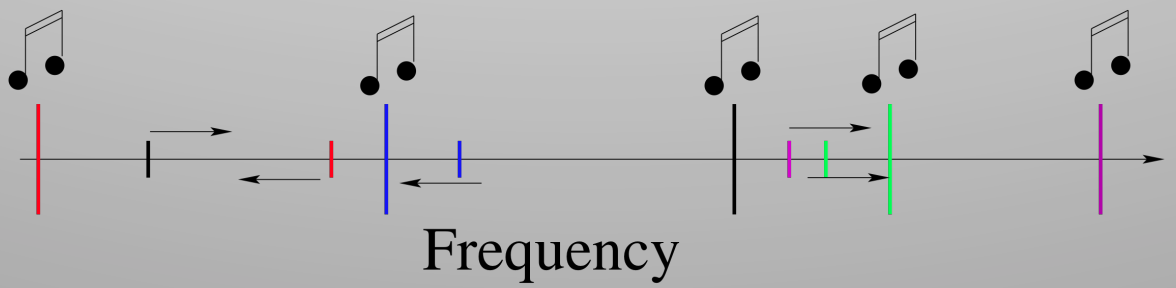
Frequency

The effect we measured can be explained by generalized synchronization of coupled oscillators!

We repeated the experiment with women football teams

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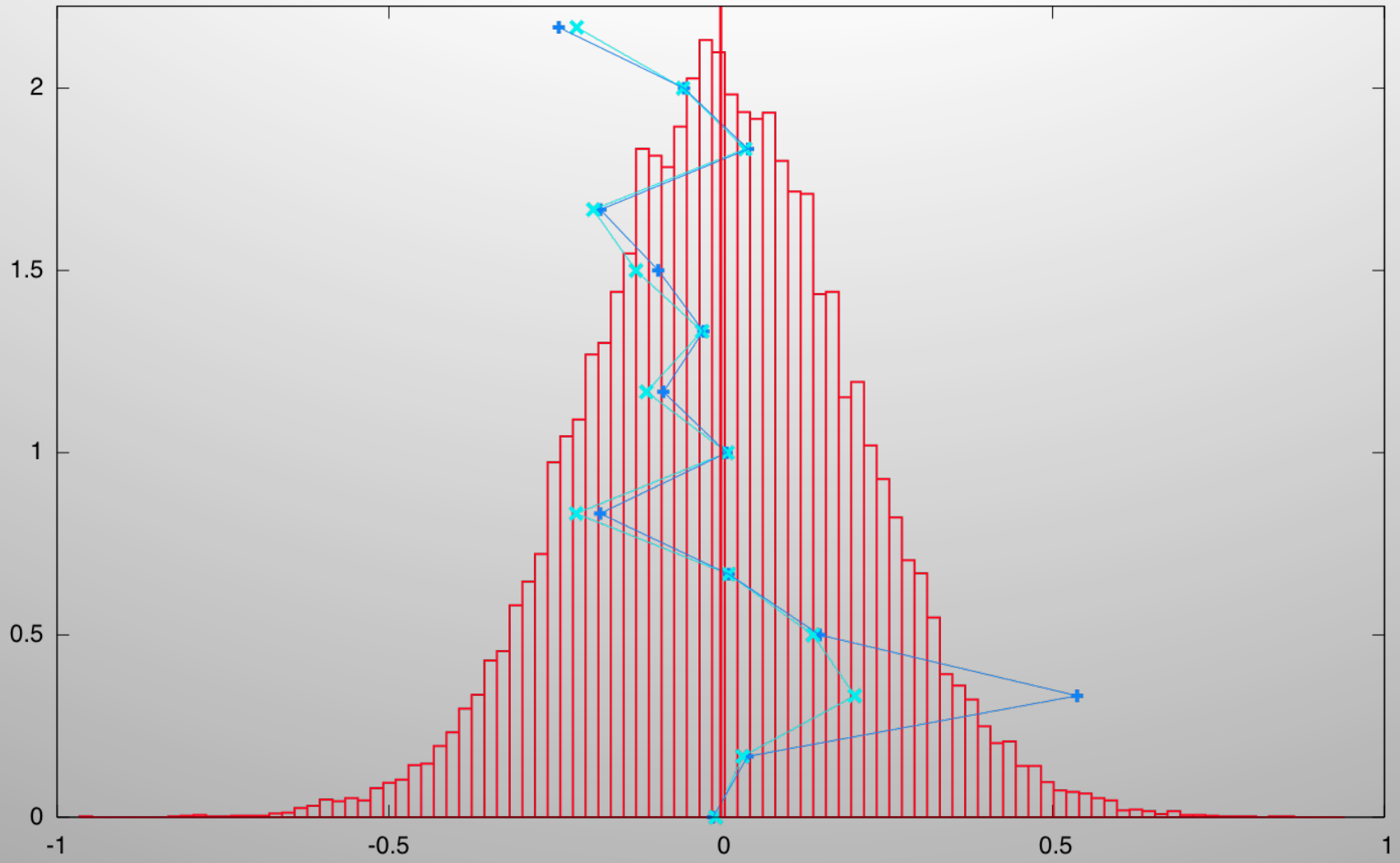
In total 14 female matches have been performed

RESULTS: significance of the collectivity according the non-parametric Mann-Whitney-Wilcoxon-rank test:

without Music – Sync	without Music – Async	Sync – Async
35.5%	38.6%	33.2%



Significance: MWWUrtest

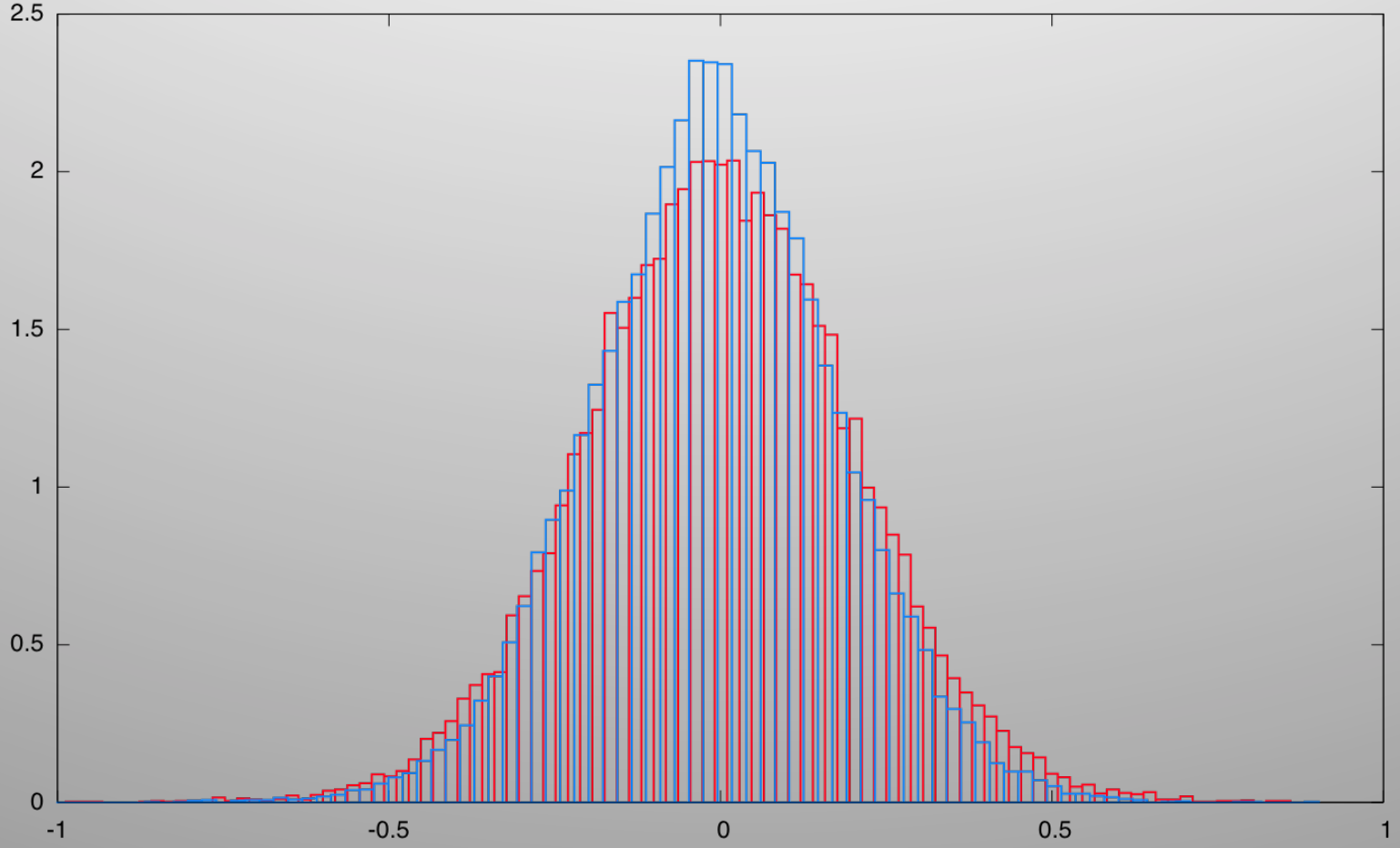
Team A 42 %

Team B 31 %

Significance of goal-difference is about 25 %

$$S_A = \frac{C_A^{Sy}}{C_B^{As}} - \frac{C_A^{As}}{C_B^{Sy}}$$

Synchron-Asynchron versus null hypothesis



$$S_A = \frac{C_A^{As}}{C_B^{wM}} - \frac{C_A^{wM}}{C_B^{As}}$$

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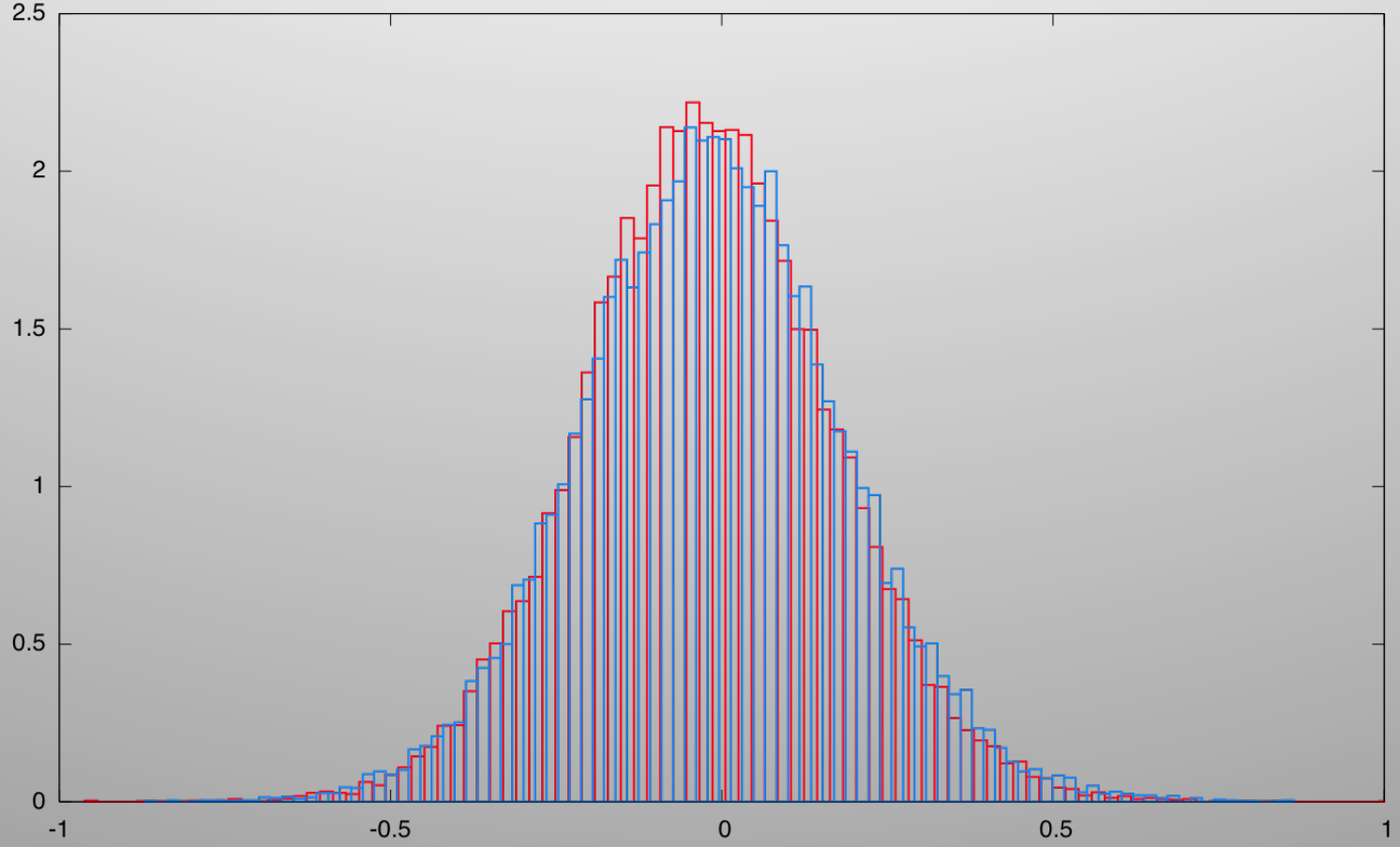
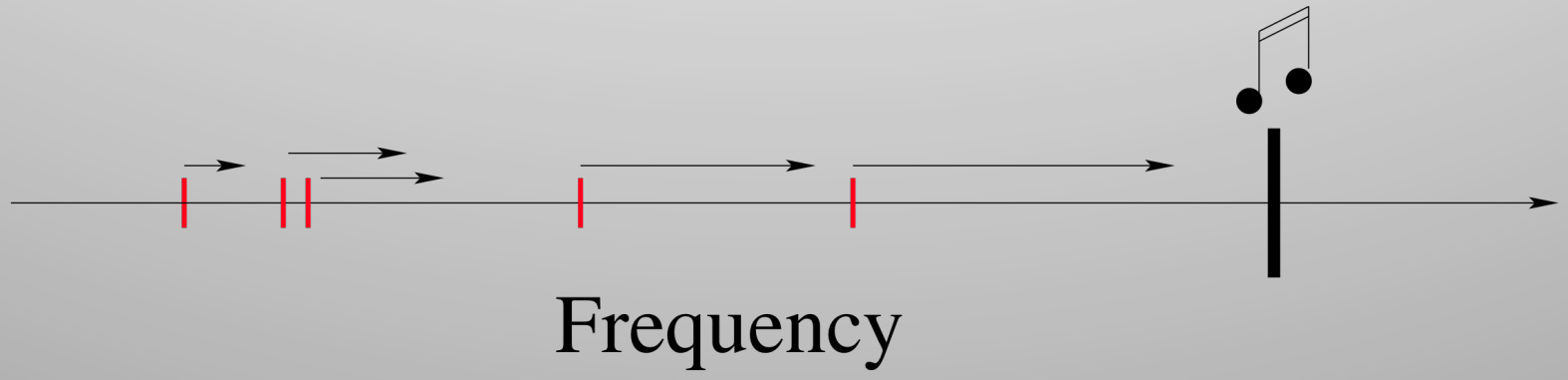
Asynchron-without Music and Synchron-without Music



What about more classical indicators like goals and number of passes?

	without Stimulus	Synchron	Asynchron
Goals	109	132	134
Passes	1831	1852	1795

If the main frequency of the acoustic stimulus is far outside the range of the dominant movement frequencies, the stimulus provokes a dispersion of movement rhythms and, hence, the probability for generalized synchronization decreases



Another hypothesis is, that the acoustic stimulus modulates the amount of attention of the soccer player.

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Internal representation of time?

Are women faster?

Are there differences between the perception of the environment between men and women?

CONCLUSIONS

The results might have practical impact.

Fundamental questions are touched, as i.e. the internal representation of time.

MANY THANKS TO ALL OF THE PEOPLE INVOLVED IN THIS PROJECT AND WHICH HELPED TO REALIZE THIS STUDY!!!

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