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## **Restoring walking complexity in older adults through arm-in-arm walking: Were Almurad et al.'s (2018) results an artifact?**

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### **Abstract**

The analysis of stride series revealed a loss of complexity in older people, which correlated with the falling propensity. A recent experiment evidenced an increase of walking complexity in older participants, when they walked in close synchrony with a younger companion. Moreover, a prolonged experience of such synchronized walking yielded a persistent restoration of complexity. This result, however, was obtained with a unique healthy partner, and could be related to a particular partner's behavior. Our aim was to replicate this important finding, using a different healthy partner, and to compare the results to those previously obtained. We successfully replicated the previous results: synchronization yielded an attraction of participants' complexity towards that of their partner, and a restoration of complexity that persisted in two post-tests, two and six weeks after the end of the training sessions. This study shows that this protocol of complexity restoration can be applied successfully with another partner, and allows concluding to its possible generalizability.

Key words: Complexity matching, restoration of complexity, interpersonal coordination, walking, rehabilitation

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### **Introduction**

Complexity is considered an essential feature for living systems, providing them with both robustness and adaptability (Whitacre, 2010). As such, complexity represents an important scope for research focusing on evolution (Whitacre & Bender, 2010), or health (Lipsitz & Goldberger, 1992). Goldberger, Peng, and Lipsitz (2002) developed the hypothesis of the loss of complexity with aging and disease (see also Harrison & Stergiou, 2015; Stergiou & Decker, 2011), and more specifically Hausdorff, Edelberg, Mitchell, Goldberger and Wei (1997) showed a typical decrease of complexity in stride duration dynamics in elderly, and showed that this decrease in complexity correlated with falling propensity (see also Hausdorff, 2007; Herman, Giladi, Gurevich & Hausdorff, 2005; Kurz, Markopoulou & Stergiou et al., 2010; Buzzi et al., 2003).

Almurad, Roume, Blain and Delignières (2018) explored the hypothesis of a possible restoration of walking complexity in older people. This work was based on the framework of complexity matching, initially introduced by West, Geneston and Grigolini (2008). The complexity matching effect states that information transfer is maximized when interacting systems share similar complexity levels. Marmelat and Delignières (2012) proposed an additional hypothesis, suggesting that interacting systems tend to harmonize their complexities in order to improve their synchronization. This effect has been evidenced in several experiments (Abney, Paxton, Dale & Kello, 2014; Almurad, Roume & Delignières, 2017; Coey, Washburn, Hassebrock & Richardson, 2016; Delignières & Marmelat, 2014; Marmelat & Delignières, 2012; Stephen, Stepp, Dixon & Turvey, 2008). Especially, Almurad et al. (2017) showed that walking in synchrony, side-by-side, was effectively governed by a complexity matching effect, revealed by a close attunement of the complexities of the two partners. They also evidenced that the complexity matching effect increased with coupling strength, and was stronger in close arm-in-arm walking than in just side-by-side walking. Note that in a similar protocol, Nessler et al. (2011) evidenced an alteration of walking complexity in both participants, which was interpreted as the result of the active control of synchronization. The authors, however, did not check for a possible convergence of complexity levels within the dyads, which represents the typical signature of complexity matching.

More interestingly for the present purpose, Mahmoodi, West and Grigolini (2018, 2020) formally showed that when two systems with different complexity levels interact, the least complex system is “attracted” by the most complex, yielding an increase of the complexity of the former. This theoretical hypothesis was experimentally tested by Almurad et al. (2018) who showed that a prolonged training of walking in synchrony with a young and healthy companion allowed restoring walking complexity in older participants. In this experiment, elderly participants were invited to walk in close synchrony, arm-in-arm, with a young experimenter. The experiment lasted 4 weeks, with 3 sessions per week. Results confirmed that synchronization was achieved through complexity matching, and that during synchronization bouts, walking complexity in participants tended to match that of the experimenter. The evolution of the intrinsic complexity of walking was assessed during bouts performed in isolation at the beginning of each week: results showed a significant restoration of complexity at the beginning of the fourth week, and this effect was persistent in a post-test performed two weeks after the end of the training sessions.

However, a potential bias of this experiment was related to the fact that a unique individual served as companion for all participants, yielding a possible artifact in the obtained results. The main aim of the present work was to replicate this experiment, in a protocol in which participants were accompanied by another young guide. In addition, we completed the previous protocol by performing two additional post-tests, four weeks and six weeks after the end of the training sessions, in order to assess the medium-term persistence of the obtained effect. Finally, we compared the data obtained in the present experiment with those of Almurad et al. (2018), in order to check for possible differences in the evolution of participants’ walking complexity in the two experiments.

The experimental hypotheses were the following:

- If an older person is invited to walk in synchrony, arm-in-arm with a healthy companion, we should observe a complexity matching effect within the dyad.
- Considering the asymmetry of complexities (older participants exhibiting lower levels of complexity than their companion), complexity matching should result in an increase of complexity in the older person.

- A prolonged training of walking in synchrony with healthy partners should induce a perennial restoration of complexity in older participants.

## **Materials and Methods**

### *Participants*

Almurad et al. (2018), in a within factor ANOVA with repeated measures, obtained an effect size of Cohen's  $d = 0.48$ . In order to replicate this effect size, with 95% power, 12 participants should be necessary (G-Power, Faul et al., 2017). 12 participants (4 male and 8 female, mean age: 72.0 yrs,  $SD = 8.13$ ) were then involved in the study. They were recruited within associations or via advertisements with health professionals. They presented no contraindication to the practice of autonomous walking (musculoskeletal, cardiovascular, respiratory or neurological pathologies). They were randomly assigned to two groups, experimental and control. One of the participants of the control group, however, was unable, for health reasons, to complete the whole protocol and was excluded from statistical analyses. Finally, the experimental group included 6 participants (1 male and 5 female, mean age: 69.83 yrs,  $SD = \pm 7.2$ , mean weight: 78.33 kg,  $SD = 12.5$ , mean height: 166.67cm,  $SD = 11.5$ ), and the control group 5 participants (2 male and 3 female, mean age: 75 yrs,  $SD = 8.8$ , mean weight: 74 kg,  $SD = 10.4$ , mean height: 165.2 cm,  $SD = 10.3$ ). The healthy guide was a female (28 years old, weight: 58 kg, height: 168 cm).

This study was conducted in accordance with the 1964 Helsinki Declaration and validated by the Euromov International Review Committee (No. 1711C). Participants signed an informed consent form and were not rewarded for their participation.

### *Experimental procedure*

For this study, we strictly followed the protocol of Almurad et al. (2018) in order to check its validity and reliability. The experiment was performed on a covered athletic track (circumference 200 m). Participants were asked to perform walking training during four consecutive weeks. Each week included three training sessions, on Monday, Wednesday and Friday. During each session, participants had to perform four 15-minutes walking sequences. On the Monday session, participants started with a solo sequence in which he/she had to walk alone, in the most regular way, for 15 minutes, at his/her preferred speed. This solo sequence allowed us to evaluate the complexity of the series of stride durations produced by the participant at the beginning of each week.

Each participant was accompanied by the guide for all the other walking sequences (3 sequences on Monday, 4 sequences on Wednesday and 4 sequences on Friday). Participants in the experimental group walked arm-in-arm with the young guide (see Figure 1) with an explicit instruction to synchronize their steps with those of their guide. Participants in the control group walked next to an experimenter without physical contact and without any synchronization instruction. For both groups, the experimenter adapted her walking speed to that of the participant.



Figure 1: Illustration of the arm-in-arm walking condition. The participants are explicitly instructed to synchronize their steps with those of their guide.

Between two successive walking sequences, participants had a rest of about 10-15 minutes. All participants performed the same amount of training (44 sequences, 12 hours of walking). The difference between the experimental group and the control group was only in terms of physical contact and synchronization of steps during walking.

Participants performed a post-test (solo sequence), two weeks after the end of the protocol (week 7). For the experimental group, we added two supplementary post-tests the first one four weeks after the end of the protocol (week 9) and the second one six weeks after the end of the protocol (week 11).

#### *Data collection*

We recorded data via two soles containing force-sensitive resistors (FSRs), posited at the heel. The soles were connected to a Schmitt trigger (LM 393AN), a device that makes the linear signal of the FSR sensors as an (on/off) switch via a voltage threshold. The output of the Schmitt trigger was connected to the GPIO interface of a Raspberry Pi model A+. A Wi-Fi dongle (EDIMAX EW7811Un) connected to the USB port of the Raspberry was configured as a Hotspot, which allowed to launch and distance the two devices. We have developed a small box containing the Raspberry Pi, the Schmitt trigger and a battery (2000 mAh). This device was put in a bag worn on the belt of the participants during training. The bag in its entirety weighted 0,4kg.

Regarding the acquisition software, we powered the Raspberry Pi by the version of the Raspbian distribution of February 9, 2016. Then, to record the data, we wrote a script in Python 3, which uses the internal clock of the Raspberry to time each touch of the heel against the ground, and then calculate the series of stride durations of the subject.

#### *Statistical analyses*

All analyses were performed on the series of stride durations of the right leg. Each raw series contained between 700 and 1400 data points. When analyzing data, we observed local trends related to periods of increase or decrease in walking speed, especially at the beginning of the series, essentially due to the time needed for participants to reach the comfortable speed for performing the test. Therefore, since fractal analyzes can be distorted due to local trends in the series, these initial acceleration/deceleration phases were removed for each series.

The resulting stride series had an average length of 647.58 points for solo sequences ( $SD = 191$ ,  $\max = 1101$ ,  $\min = 257$ ) and 633.78 points for duos sequences ( $SD = 140$ ,  $\max = 1004$ ,  $\min = 222$ ). The majority of recorded series presented the minimum number of points required for a valid fractal analysis (Delignières et al., 2006).

We first applied the Windowed Detrended Cross-Correlation (WDCC) analysis proposed by Roume et al. (2018) to assess the nature and the strength of synchronization between the dyads during the duo trials. WDCC computes the cross-correlation function within short windows of 15 points, for lags ranging from -10 to 10. Data are linearly detrended within each interval before the computation of cross-correlation coefficients. A sliding window procedure is used for obtaining multiple assessments of the cross-correlation function. WDCC functions were computed for each participant and each duo sequences, and then point-by-point averaged, for each participant, within each week. Finally, we computed a weekly averaged WDCC function across participants for each group, and we tested the signs of the cross-correlation coefficients with two-tailed location  $t$ -tests, comparing the obtained values to zero (Roume et al., 2018). In WDCC functions, the complexity matching effect is revealed by a significant positive peak at lag 0, indicating an immediate synchronization between systems. WDCC could also reveal discrete, step-to-step corrective processes: in that case positive peaks could appear at lag -1 and/or lag 1, depending of the leader/follower statuses within the dyad (Roume et al., 2018). Note that WDCC correlation coefficients could take values in the interval [-1,1].

We used the Detrended Fluctuation analysis (DFA, Peng et al., 1994) to estimate the complexity of each data series. For this analysis, we chose to start the intervals from 10 up to  $N/2$  ( $N$  being the length of the series). We used the evenly spaced DFA algorithm proposed by Almurad and Delignières (2016), which was proven to provide a better estimate of the scaling exponent, especially for short series. Note the  $\alpha$ -DFA exponents obtained in walking series are expected to vary between 0.5 and 1, the exponent approaching 1 in young and healthy participants, revealing optimal complexity. The loss of complexity is revealed by weaker exponents, 0.5 theoretically corresponding to a complete loss of complexity.

In order to assess the effects of the experimental protocol on the complexity of stride series in the solo trials, we applied a 2-factor ANOVA 2 (group) X 5 (week), with repeated measurements on the second factor (including the 4 weeks of the training protocol, and the post-test). We used the Bonferroni post-hoc test for locating significant ANOVA effects. In a second step, we applied a one-way ANOVA 7 (week), with repeated measurements, for assessing the persistence of the effects of synchronized walking in the experimental group over the three post-tests performed after the end of the rehabilitation protocol.

Finally, in order to compare our data with that obtained by Almurad et al. (2018), we applied a 3-factor ANOVA 2 (group) X 5 (week) X 2 (guide), with repeated measurements on the second factor (including the 4 weeks of the protocol and the first post-test). We used the Bonferroni post-hoc test for locating significant ANOVA effects.

## Results

We confirmed that synchronized walking was dominated by a complexity matching effect. In all cases, the weakly averaged WDCC functions presented a positive peak at lag 0, revealing the immediate synchronization expected from a complexity matching effect (Figure 2). However, this peak had a higher average value for the experimental group (about 0.3) than in the control group (about 0.1). The lower value obtained in the control group suggested a less marked, even intermittent synchronization. In the experimental group, these functions also revealed a significant positive peak at lag 1 during the first and the third week. This phenomenon is not noticeable in the control group.

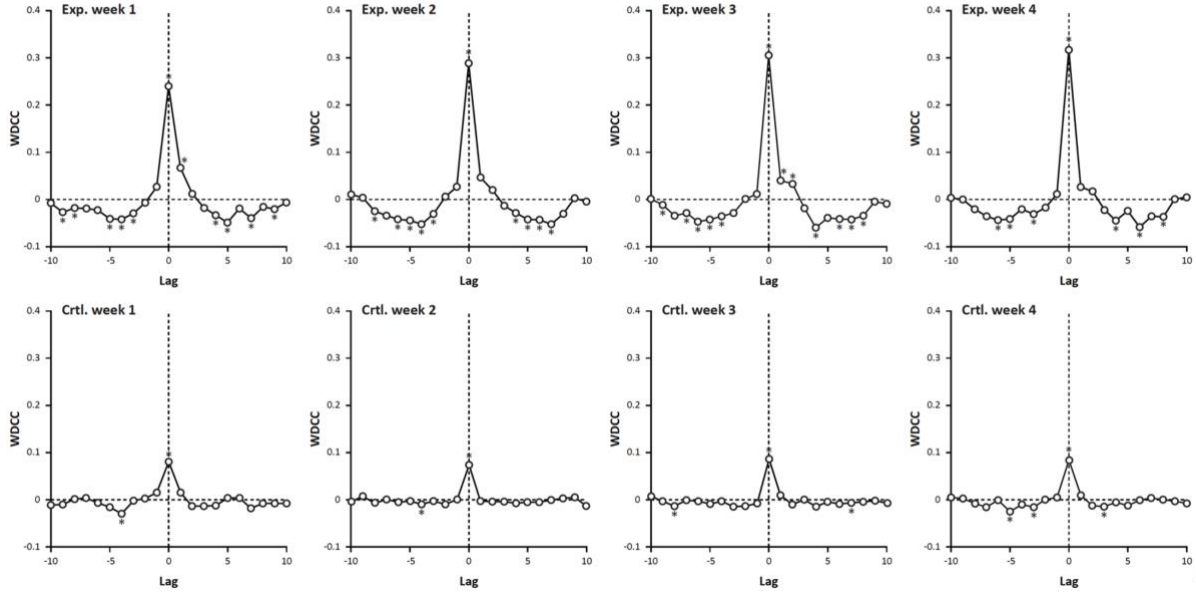


Figure 2 : Evolution of the averaged Windowed Detrended Cross-Correlation function, for the experimental group ( $n = 6$ ; top row) and the control group ( $n = 5$ ; bottom row), over the four weeks of training. A positive peak in lag 0 reveals the presence of a complexity matching effect. The sign of the mean cross-correlation coefficients was tested with two-tailed location  $t$ -tests, comparing the obtained values to zero (\*:  $p < .05$ ).

This study confirmed that a prolonged experience of close synchronized walking, with a young and healthy guide, allowed restoring walking complexity in elderly participants, and that this effect persisted two weeks after the end of the training sessions: The ANOVA revealed a significant interaction between group and week ( $F(4,36) = 4.413$ ,  $p = 0.005$ , partial  $\eta^2 = 0.329$ ), and the Bonferroni post-hoc test showed a significant difference between the mean  $\alpha$ -DFA obtained in the experimental group during the fourth week and the post-test on the one hand, and the means  $\alpha$ -DFA on weeks 1 and 2 ( $p < 0.01$ ). We report in Table 1 the averages and standard deviations of  $\alpha$ -DFA estimates, for each group and each solo sequence, for the four weeks of the training protocol and the first post-test (week 7), and in Table 2 the results of the 2-factor ANOVA performed on the related samples. These results are illustrated in Figure 3.

Table 1: Mean  $\alpha$ -DFA estimates (standard deviations in brackets), for each group and each solo sequence, for the four weeks of the experiment and the first post-test. An  $\alpha$ -DFA close to 1 corresponds to an optimal complexity, any decrease in this exponent reveals a loss of complexity. A total loss of complexity should be revealed by  $\alpha$ -DFA close to 0.5.

Group	Week 1	Week 2	Week 3	Week 4	Post-test
Experimental group ( $n = 6$ )	0.777 (0.073)	0.798 (0.109)	0.863 (0.087)	0.959 (0.097)	0.964 (0.075)
Control group ( $n = 5$ )	0.845 (0.063)	0.810 (0.145)	0.808 (0.043)	0.837 (0.047)	0.827 (0.048)

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Table 2: Results of the 2-factor ANOVA 2 (group) X 5 (week)

Source	df	$F$	$p$	partial $\eta^2$
Group	1	1.715	.222	0.160
Error	9			
Week	4	4.816	.003	0.349
Week X Group	4	4.413	.005	0.329
Error	36			

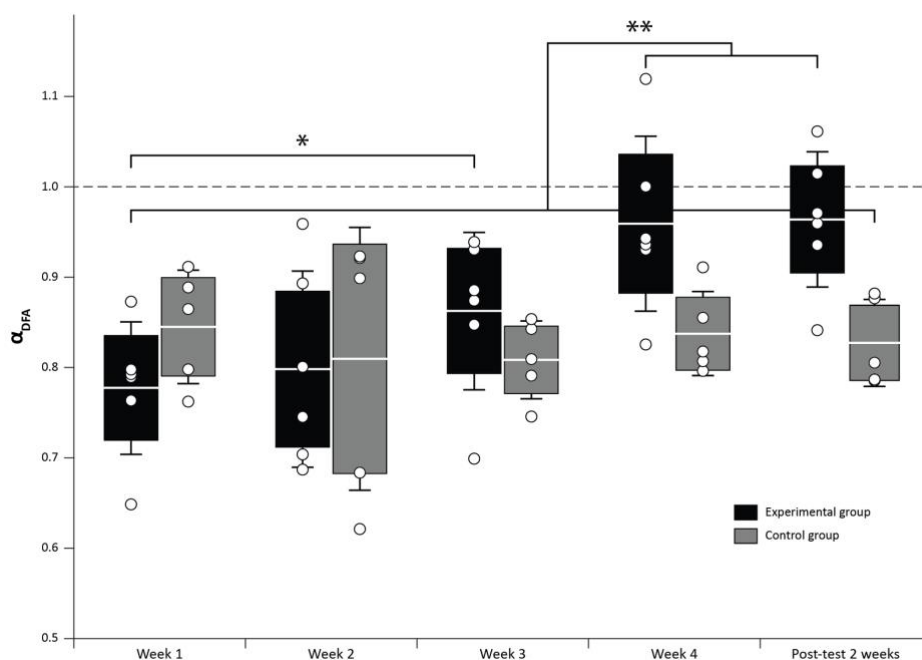


Figure 3: Evolution of  $\alpha$ -DFA exponents computed for participants in solo sequences (black: experimental group, grey: control group), over the four training weeks and the post-test (week 7). The interaction Group X Week was significant ( $F(4,36) = 4.413$ ,  $p = 0.005$ , partial  $\eta^2 = 0.329$ ). This figure highlights the significant improvement in  $\alpha$ -DFA exponents in the experimental group, revealing a restoration of the complexity of walking from the 4<sup>th</sup> week of the experiment up to 2 weeks post-protocol. This graph presents a combination of boxplots and scatter plots (Campbell, notBoxPlot <https://www.github.com/raacampbell/notBoxPlot>). \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ .

We report in Figure 4 the evolution of the mean  $\alpha$ -DFA exponents during the four weeks of the training protocol, for both solo and duo sequences. The left graph represents the results for the experimental group, and the right one for the control group. As the “guide” data were obtained from a unique individual, statistical analyses were not applicable. These graphs, however, highlight the lower level of complexity of participants, during the solo sequences, especially at the beginning of the experiment, as compared to that of their guide. They also illustrate the attraction of participants’ complexity toward that of their guide during duo sequences, in the experimental group. This convergence appears less noticeable in the control group. Finally, the level of the average  $\alpha$ -DFA exponent in the experimental group reached at the beginning of the fourth week the level of the guide, in the solo test, which was not the case for the control group.

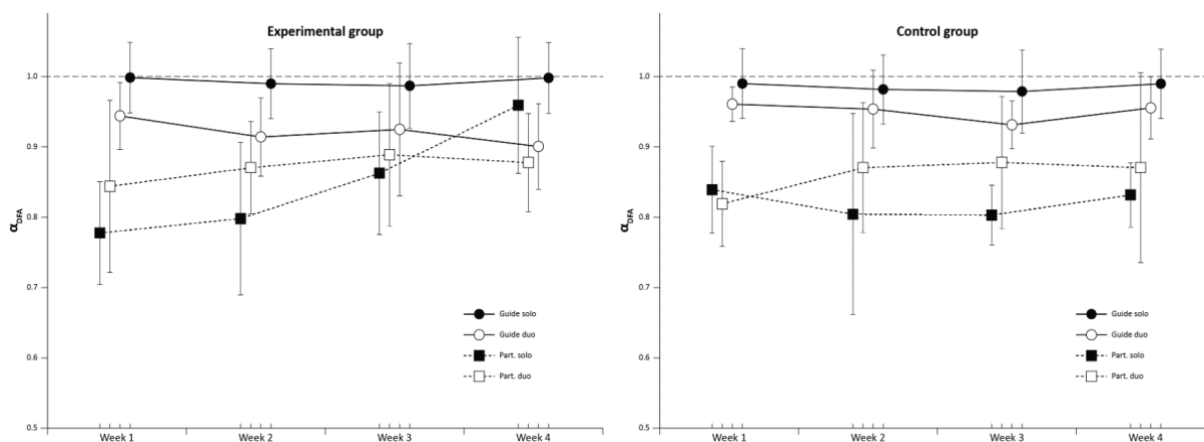


Figure 4: Average  $\alpha$ -DFA exponents computed for guides (circles) and participants (squares) in solo sequences (black) and duo sequences (white), over the four training weeks. Results are displayed for the experimental group (left) and the control group (right). Error bars represent standard deviation. This figures notably illustrates the attraction of participants' complexity toward that of their guide during duo sequences, in the experimental group. This convergence appears less noticeable in the control group.

The analysis of the evolution of the  $\alpha$ -DFA exponent, in the experimental group, during the 4 weeks of the training protocol, and the three subsequent post-tests, showed a persistence of the complexity restoration effect up to 6 weeks after the end of the training (Figure 5). The ANOVA revealed a significant effect ( $F(6,30) = 6.119$ ,  $p = 0.0002$ , partial  $\eta^2 = 0.550$ ), and the post-hoc test showed that the mean  $\alpha$ -DFA exponent was higher during the solo test performed at the beginning of the fourth week and during the post-tests performed at week 7 and week 11, as compared with the first week of the protocol ( $p < .05$ ).

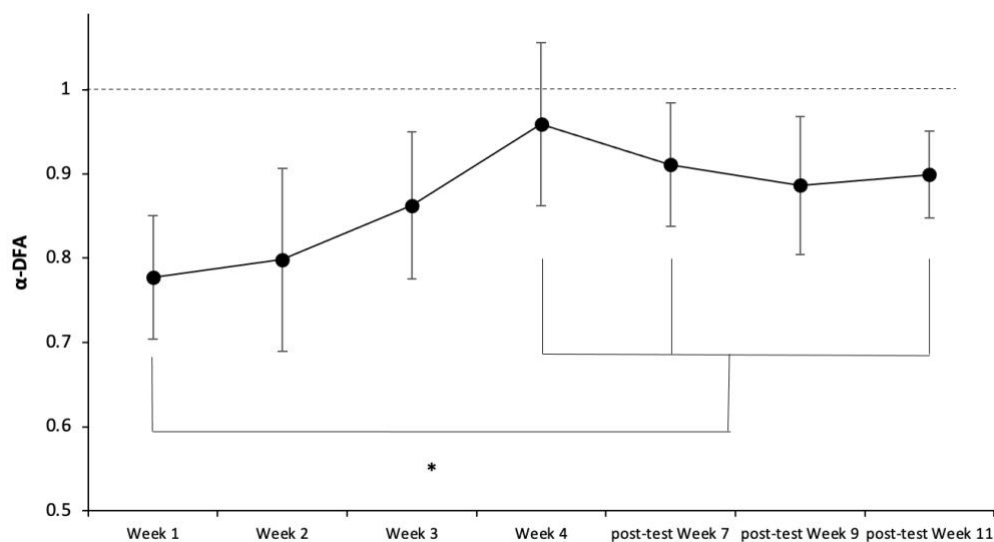


Figure 5: Average  $\alpha$ -DFA exponents computed for the experimental group in solo sequences, over the four training weeks, and the post-tests (weeks 7, 9 and 11). This graph highlights the persistence of the complexity restoration effect in the experimental group up to 6 weeks post-training. Error bars represent standard deviation. \*:  $p < .05$ .

Finally, merging our data with those obtained by Almurad et al. (2018), we evidenced a similar evolution of mean  $\alpha$ -DFA in the two experiments (Figure 6). The ANOVA did not reveal a main effect for the guide factor, nor any interaction between guide and the other factors. The analysis just showed a significant interaction between group and week ( $F(4,72) = 8.454, p = 0.0000, \text{partial } \eta^2 = 0.319$ ), and the post-hoc test revealed a significant difference between the mean  $\alpha$ -DFA obtained in the experimental groups during the fourth week on the one hand, and those obtained during the three first weeks of the training protocol ( $p < .01$ ). It also showed a significant difference between the means  $\alpha$ -DFA of the experimental groups and those of the two first weeks of the training protocol. The complete results of the 3-factor ANOVA (2 guide x 2 group x 5 week) are displayed in Table 3.

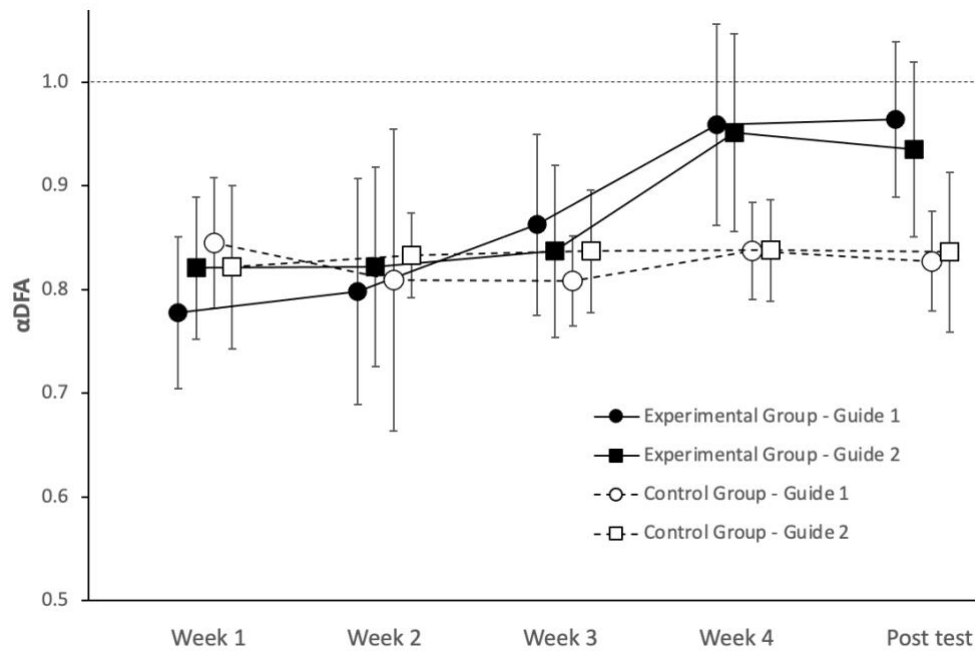


Figure 6: Average  $\alpha$ -DFA exponents computed for participants in solo sequences, over the four training weeks and the post-test. Results are displayed for the 2 experimental groups (black circles: guide 1, present experiment; black squares: guide 2, Almurad et al. (2018)'s experiment), and for the 2 control groups (white circles: guide 1; white squares: guide 2). This figure highlights the similarity of the results obtained by Almurad et al. (2018) and those of the present study. The interaction Group X Week was significant ( $F(4,124) = 8.620, p = 0.0000, \text{partial } \eta^2 = 0.218$ ). Error bars represent standard deviation.

Table 3: Results of the 3-factor ANOVA 2 (group) X 5 (week) X 2 (guide)

Source	df	$F$	$p$	partial $\eta^2$
Group	1	5.438	.026	0.149
Guide	1	0.043	.837	0.001
Group X Guide	1	0.039	.845	0.001
Error	31			
Week	4	10.668	.000	0.256
Week X Group	4	8.620	.000	0.218
Week X Guide	4	0.328	.859	0.010
Week X Group X Guide	4	0.960	.432	0.030
Error	124			

## Discussion

The hypotheses of this study were clearly validated: When we invite an older person to walk in synchrony, arm-in-arm, with a young and healthy partner, synchronization is mainly dominated by a complexity matching effect. We were able to check this hypothesis by the WDCC analysis. This function revealed a positive peak at lag 0 showing an immediate synchronization between systems, which represents the typical signature of complexity matching. This peak at lag 0 appeared in both groups, but was higher in the experimental group, confirming that the complexity matching effect is related to the strength of coupling between partners. We noticed, however, that the peak at lag 0 for the control group was weaker than that reported in Almurad et al. (2018). This could be due to an experimenter effect influencing the strength of synchronization in the dyad. Finally, the complexity matching effect was present from the very first duo sequences performed during the training protocol, indicating that this effect appeared spontaneously, and was not the result of a specific learning. These results confirm those of Almurad et al. (2018). The positive peak that appears at lag 1 in the WDCC functions for the experimental suggests that participants tended, in addition to the complexity matching synchronization, to correct their steps on the basis on the preceding asynchrony. This discrete correction process remains marginal, however, and synchronization seemed mainly achieved through complexity matching.

The attraction of participants' complexity toward that of their guide represents a nice experimental validation of the formal result of Mahmoodi et al (2020), stating that when two systems of different levels of complexity interact, the most complex tends to attract the less one. The present results confirm that this effect depends on the strength of coupling between the two systems in interaction.

We confirm that the prolonged experience of complexity matching allows restoring walking complexity in elderly, as evidenced by the increase of DFA exponents at the beginning of the fourth week and during the post-test. This experiment and the previous work by Almurad et al (2018) indicate that three weeks of intensive practice could be sufficient for obtaining a significant restoration of complexity. The absence of any significant evolution of scaling exponents in the control group shows that the complexity matching effect is essential in the restoration of complexity, and that physical activity alone is not sufficient for inducing any effect on the complexity of stride dynamics (the control group having carried out the same training load than the experimental group).

Several experiments were recently conducted for exploring the effects of walking in synchronization with artificial devices, mimicking the complexity of healthy natural gait (fractal-like metronomes), for walking rehabilitation in older people (e.g., Kaipust, McGrath, Mukherjee, & Stergiou, 2013; Vaz, Knarr, & Stergiou, 2020). Generally, one effectively observes an increase of walking complexity during synchronization. However, is synchronization with an irregular, fractal-like metronome really equivalent to the synchronization with a human partner? Delignières and Marmelat (2014) showed that walking in synchronization with a fractal metronome was essentially performed through discrete step-to-step asynchrony corrections (revealed by positive peaks at lag-1 and lag-2 in the WDCC function), but they did not observe any evidence of complexity matching effect. As stated previously, our results suggest that a prolonged experience of complexity matching represents the key of a lasting complexity restoration. We are not sure that the use of a metronome, even perfectly mimicking natural variability, can give the same result. Interestingly, however, Vaz et al. (2020) observed an increase of walking complexity in older participants walking in synchrony with a visual fractal-like metronome, and showed that this improvement was retained, as least for some minutes, when the stimulus was turned off.

Further research efforts are necessary for testing the durability of this apparent restoration of complexity, and to reveal the nature of the processes at work for ensuring synchronization.

We have shown that our results are similar to those obtained by Almurad et al. (2018): This effect of complexity restoration was not related to particular guide's behavior, and could be replicated with another guide. This represents an essential point, allowing to pursue with some confidence the rehabilitation perspectives offered by this kind of protocol. Finally, our results show that the effect of restoration is preserved up to 6 weeks post-protocol. This medium-term persistence, which was not tested in the previous experiment, represents a very encouraging result for rehabilitation purposes.

The number of participants in this experiment remained modest, but our main goal was to replicate the experiment and check for the absence of any artifact, in order to validate the protocol. Note that despite the loss of one participant during the experiment, the effect size remains quite satisfactory ( $d = 0.62$ ), of medium level according to the classification of Cohen (2013).

We are aware, however, that the scope of these experiments remains limited to a quite fundamental issue: is it possible, by means of the complexity matching effect, to restore complexity in deficient systems? The protocol we tested is very challenging for participants (approximately 36 km of walking during the four weeks). For evident reasons, we recruited participants in a population of elderly people with non-pathologic aging and a moderate loss of complexity. Additional efforts are obviously needed for adapting and testing this kind of protocol for frailer patients (older individuals, Parkinsonian patients, etc.).

The present results show that a restoration of complexity is conceivable, and one could think that this enhancement in complexity should induce a more stable and adaptable walking, and a reduction of falling propensity in elderly. Clinical evidences are still lacking, however, and we have engaged a new experiment for studying the impact of this arm-in-arm synchronized walking protocol on clinical measures assessing the risk of falling.

Finally, we have no indication about the durability of this restoration, beyond the six weeks, which separate the end of the training and the third post-test. Our current projects aim at checking this durability, with delayed post-tests up to 2 months post-protocol.

## **Conclusion**

This work remains fundamental in nature but obviously opens essential perspectives at the clinical level. The present results allow to pursue with more confidence these clinical perspectives. We would like to emphasize that the operational implementation of this protocol remains very affordable financially since it does not require any expensive technology but simply young volunteers in good health. We believe that this intergenerational link could be an effective and cheap way to preventing the fall of our seniors.

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## **Declaration of Interest statement**

The authors declare no conflict of interest.

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