Positive expectation improves perception of mental and physical fatigue in a sequence learning task

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Introduction

The placebo effect could be defined as a beneficial outcome that follows the administration of a treatment and that is not to be ascribed to active ingredients but to the words, contexts and beliefs that surround the treatment (Benedetti et al., 2011). The placebo effect has been able to modulate some motor performances such as force production or movement speed among others (Fiorio et al., 2018). However, it is still lacking whether the placebo effect can modulate other motor parameters. Motor skill learning is a crucial function that allows us to acquire well-performed skills (Dayan & Cohen, 2011). It is associated to a change in motor functions, like the acquisition of higher speed (Dahms et al., 2020) and to the deployment of cognitive functions, like concentration to the movements performed (Doyon et al., 2003). Moreover, during extensive repetition of a task, fatigue often arises and it can entails a physical (physical fatigue) and a cognitive component (mental fatigue) (Janet, 2012).

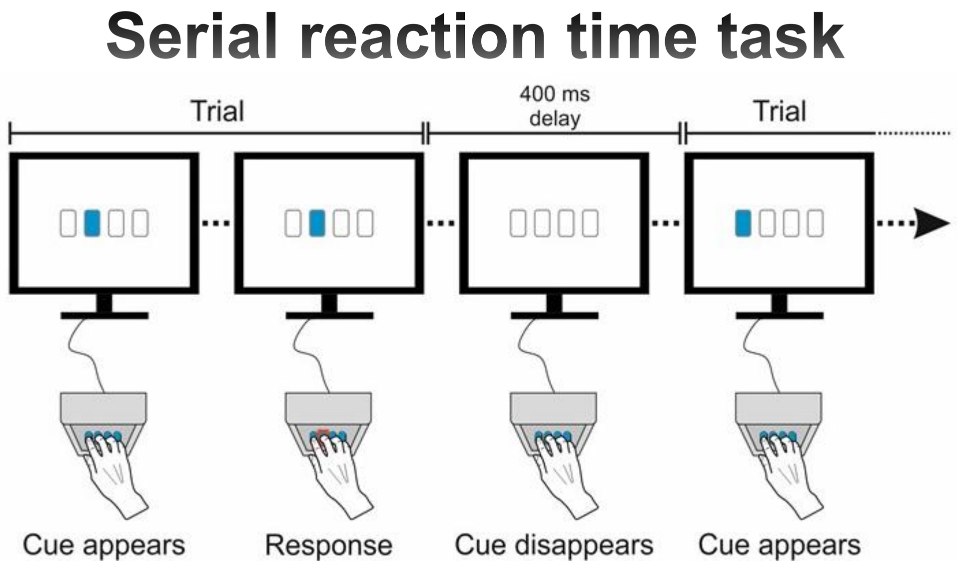
Aims

- To investigate whether motor skill learning as well as perception of physical or mental fatigue could be improved by a placebo intervention.
- To tackle the specific contribution of the placebo effect on the motor or cognitive components of motor skill learning.

Materials and Method

90 healthy volunteers (44 females; mean ± SD: 21.12 ± 2.42 years). 30 participants in each group. Furthermore, a subgroup of 45 total participants (15 of each group) perform a consolidation session 24 hours after the main experiment.

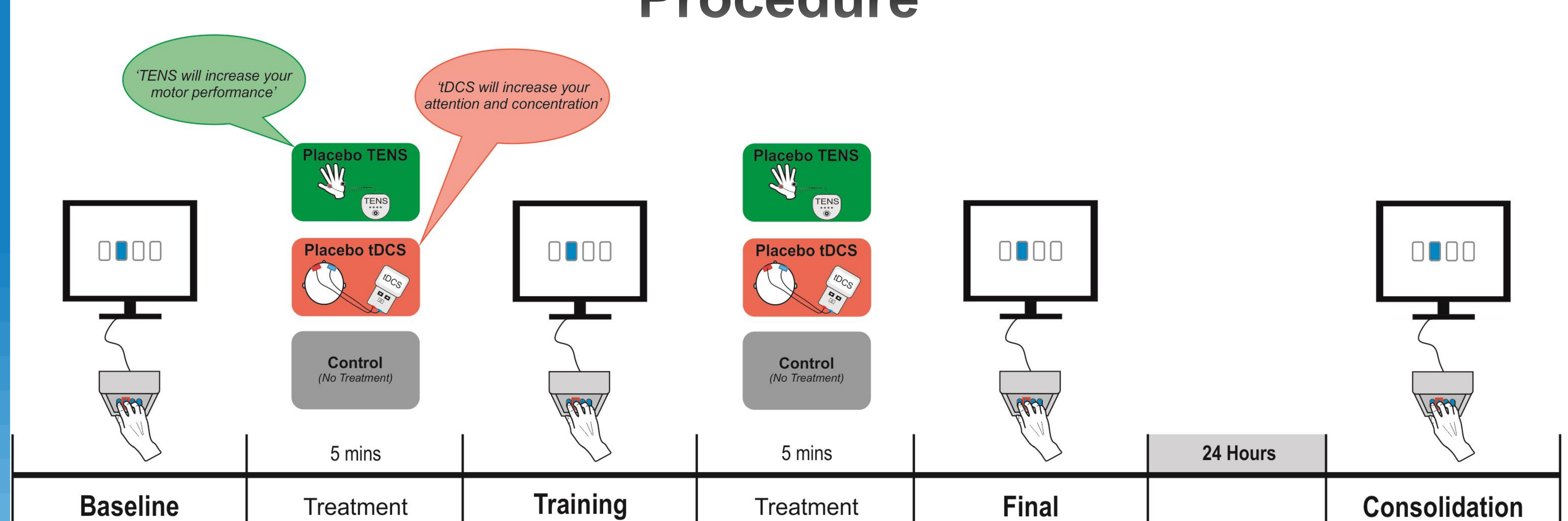
Serial reaction time task



Subjects had to respond as quickly and as accurately as possible by pressing the button on the pad that correspond to the appeared visual cue.

Sequence *(2-3-1-4-3-2-4-1-3-4-2-1)* sandwiched between 2 random blocks in each session.

Procedure



Objective Parameters

Reaction time (RT): time between the onset of the visual cue and the press of the correct button. (Random and Sequence)

Proportion of error (PE): number of incorrect button press: N(error)/N(total). (Random and Sequence)

LISAS: linear integrated speed-accuracy score (*Vandierendonck, 2017*)

$$\mathrm{LISAS} = \mathrm{RT}_c + \mathrm{PE} \times \frac{S_{\mathrm{RT}}}{S_{\mathrm{PE}}}$$

RT_c = reaction time of correct response
PE = proportion of error
S_{RT} = standard deviation of RT
S_{PE} = standard deviation of error

Subjective Parameters

Perception of physical fatigue

Mentally, how much fatigue did you perceived?

-3 Much Fatigue | -2 | -1 | 0 As baseline | +1 | +2 | +3 Much Energy

Perception of physical fatigue

Physically, how much fatigue did you perceived?

-3 Much Fatigue | -2 | -1 | 0 As baseline | +1 | +2 | +3 Much Energy

Analysis of Data

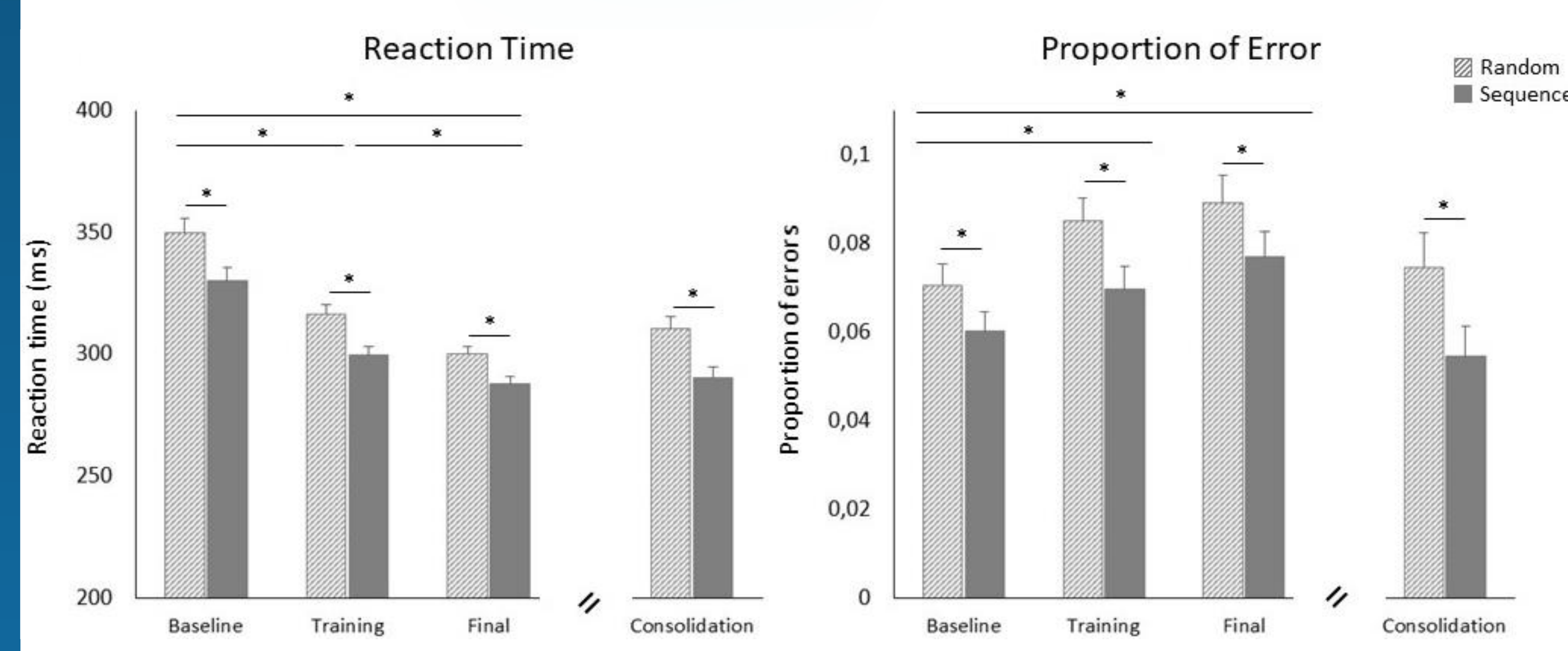
RT, PE and LISAS: repeated measure ANOVA with *Group* (Placebo-TENS, Placebo-tDCS, Control) as between-subject factor; and *Type* (Random, Sequence) and *Session* (Baseline, Learning, Final) as within-subject factors.

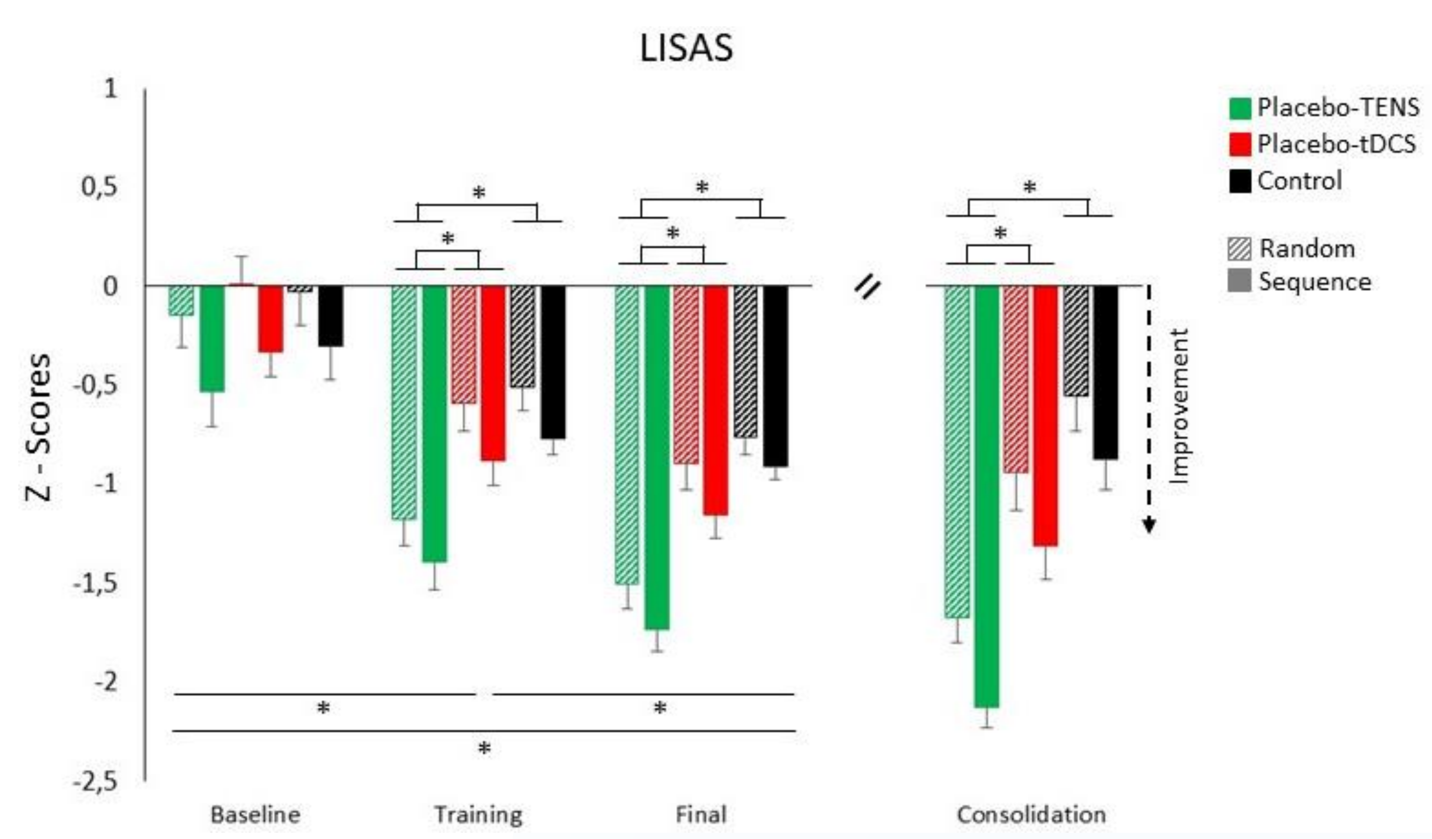
Physical and Mental Fatigue: Kruskal-WallisTest: analysis between groups (Placebo-TENS, Placebo-tDCS, Control) in each session separately. Friedman Test: analysis within each group separately of sessions (T0, T1, T2)

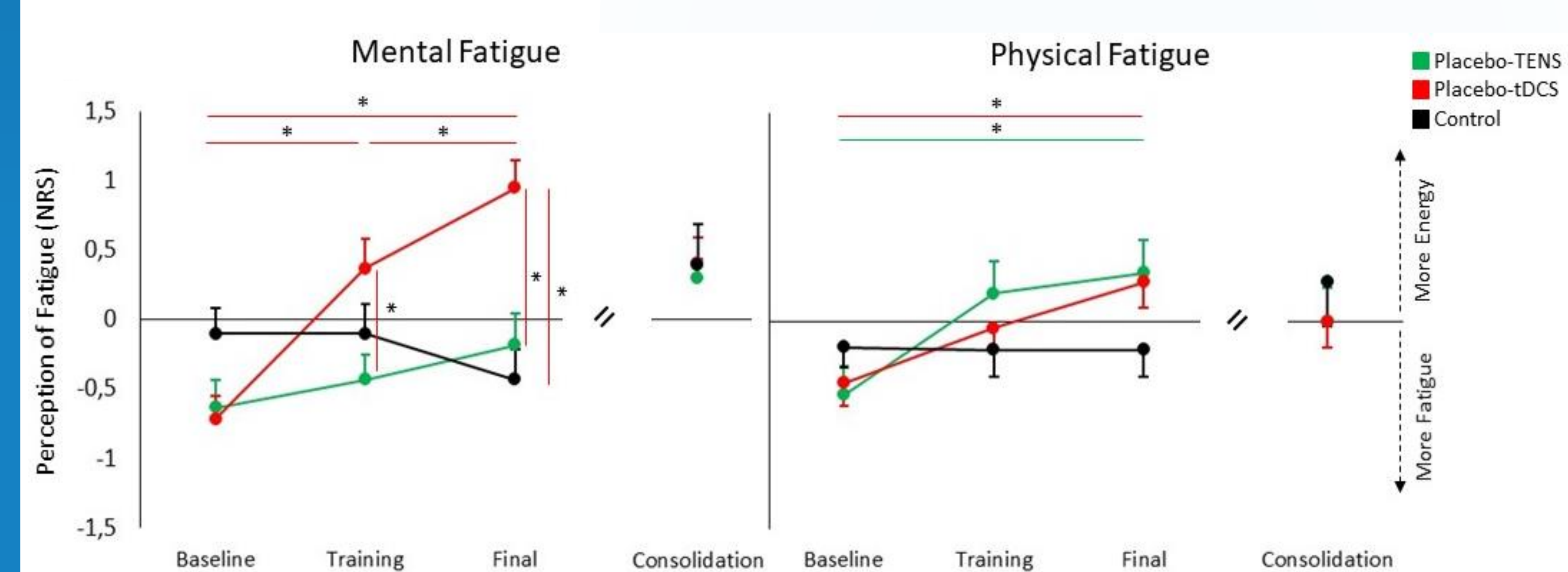
Post-hoc comparisons: independent t-test, paired t-test and Wilcoxon Signed Rank Test and Mann-Whitney U Test.

Bonferroni correction and the level of significance was set at $p \leq 0.05$. Data are represented as mean values ± SE.

Results







Discussion

- A significant overall improvement of reaction time was found in all groups. Particularly, subjects were faster across sessions. Moreover, their responses were significantly faster for the sequence than for random order of stimulus. However, we found also a significant increased of the proportion of error across sessions.
- By combining RT and proportion of errors with the linear integrated speed-accuracy scores (LISAS), we obtained a reliable picture of performance (Vandierendonck, 2017). We found participants who received the placebo-TENS intervention presented a more clear improvement of performance (LISAS) than the other two groups and it was not specific for the sequence trials. Hence, it appears that the placebo-TENS intervention generally improved response selection without specifically affecting sequence learning. This effect lasted 24 hours after the placebo procedure.
- More interestingly, perception of mental and physical fatigue was differently modulated by the placebo procedures, with a reduction of both mental and physical fatigue in the group that received the placebo-tDCS intervention and a selective reduction of physical fatigue in the group with the placebo-TENS intervention. The perception of both fatigue were reset after 24 hours of the main experiment.

Take-home message

Motor placebo could improve the general performance, while cognitive placebo might reduce the mental fatigue in motor skill learning.

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