Inserm

La science pour la santé
From science to health

TRANSCRANIAL MAGNETIC STIMULATION-BASED ASSESSMENT OF MENTAL TRAINING EFFECTS ON MOTOR LEARNING IN HEALTHY PARTICIPANTS

Acronym: IMAP-TMS

Protocol ID: C19-19

Registry Identifier: 2020-A00305-34

25/11/2020

Sequence 1

Protocol

Four groups will be included. Three experimental groups will perform a mental training session followed by different actual movements in immediate post-test, depending on their groups: i) manual motor sequence, identical to the pre-test, ii) manual motor sequence, different from the pre-test, and iii) isometric muscle contractions (strength). The control group will not perform mental training but will perform all the test sessions. On Day 1, we will first conduct the KVIQ to measure the imagery abilities of the participants, as well as the Edinburgh laterality questionnaire to measure manual lateralization. Then we will carry out the first TMS recordings, followed by a pre-test phase. This pre-test phase will consist, for all the participants, in the physical execution of a manual sequence at a frequency of 0.5 Hz. The number of errors and omissions, as well as the respect of the tempo will be considered as measures of performance. Participants will then proceed to the mental training phase. For all mental training groups, this will consist in imagining the sequence performed in pre-test. The participants will imagine 100 sequences during the mental training phase. Following the training ("immediate" post-test phase), the participants will be divided into several experimental groups and will perform 10 actual movements, according to their group. On Days 2 to 4 of Weeks 1 & 2, the participants will follow the mental training as well as the actual movement session in immediate post-test. On Day 5 of Weeks 1 & 2, the protocol will be identical to that of Day 1. Finally, on Day 1 of the Week 3, we will carry out the final post-test and manage the final TMS recordings.

Statistical design

For the behavioral data, movement time and accuracy will be measured (pre- and post-tests), for each session. The normality of dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or Mixed Linear Models with the Test (pre and post tests) as within-subject factor and Group as between-subject factor. Post hoc tests will allow pairwise comparisons. If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow pairwise comparisons.

For the neurophysiological data (recruitment curves), the mean amplitude of the motor evoked potentials will be calculated in order to obtain recruitment curves (pre-training, immediate and delayed post-training). The normality of the dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or mixed linear models with the test (pre-training, post-training) as within-subject factor and the group as between-subject factor. Post hoc tests will allow pairwise comparisons. If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

Sequence 2

Protocol

On Day 1, we will first conduct the KVIQ to measure the imagery abilities of the participants, as well as the Edinburgh laterality questionnaire to measure manual lateralization. Then we will carry out the first TMS recordings, followed by a pre-test phase. This pre-test phase will consist, for all the participants, in manipulating the robotic arm and reaching targets presented on the screen, as accurate and quickly as possible. This experiment will involve two groups (actual and imagined trainings), themselves divided into two groups (disturbance during the preparation phase or after it). The course of a session will be composed of: (i) an initial test for which no force field will be applied, (ii) a training phase during which the force field will be applied during or after the preparatory period according to the condition and (iii) final tests in which the force field will be absent to measure consequential adaptation effects (after-effects). TMS recordings will be then performed at post-test. The pre- and post-tests will consist of 120 movements. The training phase will be composed of 240 actual or imagined movements (depending on the group) divided into 5 blocks. That protocol will take place over 10 days with 5 training sessions per week.

Statistical design

For the behavioral data, the statistical analysis will focus on three measurements calculated from the actual trials to determine the adaptation to the force field : 1) the trajectory error, which corresponds to the area under the curve of the trajectory of the hand as a function of the straight line joining the starting target and the final target; 2) the maximum deviation, which is calculated from the maximum perpendicular distance between the position of the hand and the straight line joining the starting target and the final target; 3) the final error, which corresponds to the distance between the final position of the hand and the position of the final target to be reached. The analysis will be performed on the data related to duration, accuracy, error, and acceleration parameters. The normality of dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or Mixed Linear Models with the Test (pre and post tests) as within-subject factor and Group as between-subject factor. Post hoc tests will allow for pairwise comparisons. If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

For the neurophysiological data (recruitment curves), the mean amplitude of the motor evoked potentials will be calculated in order to obtain recruitment curves (pre-training, immediate and delayed post-training). The normality of the dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or mixed linear models with the Test (pre-training, post-training) as within-subject factor and the Group as between-subject factor. Post hoc tests will allow pairwise comparisons If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

Sequence 3

Protocol

Four groups of subjects will be included: two experimental and two control groups. On Day 1, we will first conduct the KVIQ to measure the imagery abilities of the participants, as well as the Edinburgh laterality questionnaire to measure manual lateralization. After initial TMS recordings, the first experimental group will have, as a pre-test, to imagine a manual motor sequence (A) for 50 trials, undergo the protocol of PAS on Day 1 of Weeks 1 & 2 and come back to physically perform the sequence A on Days 2 to 4 of Weeks 1 & 2 (10 trials per days). The second group will have to imagine another motor sequence (B) for 50 trials, undergo the protocol of PAS to imagine the sequence (A) for 50 trials on Day 1 of Weeks 1 & 2 and come back to physically perform the sequence A on Days 2 to 4 of the Weeks 1 & 2. The motor sequences (A) and (B) consist of 5 keys, differently ordered in each sequence. The two control groups will monitor the effects of PAS and motor imagery; one group will perform the protocol without undergoing PAS on Day 1 of Weeks 1 & 2, the other will watch a documentary and undergo the PAS protocol on Day 1 of Weeks 1 & 2. Both groups will return from Days 2 to 4 of Weeks 1 & 2 to physically perform the sequence (A). Finally, participants will have to perform 10 actuals trials on Day 1 of Week 3. TMS recordings will be performed on Day 5 of Week 1 & 2, as well as on Day 1 of Week 3.

Statistical design

For the behavioral data, statistical analysis will focus on time, accuracy and error. The normality of dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or Mixed Linear Models with the Test (pre and post tests) as within-subject factor and Group as between-subject factor. Post hoc tests will allow for pairwise comparisons. If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

For the neurophysiological data (recruitment curves), the mean amplitude of the motor evoked potentials will be calculated in order to obtain recruitment curves (pre-training, immediate and delayed post-training). The normality of the dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or mixed linear models with the test (pre-training, post-training) as within-subject factor and the group as between-subject factor. Post hoc tests will allow for pairwise comparisons If the data are not normally distributed, non-parametric tests will be used: Generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

Sequence 4

Protocol

To carry out this study, four groups will be formed (3 experimental, 1 control). On Day 1, we will first conduct the KVIQ to measure the imagery abilities of the participants, as well as the Edinburgh laterality questionnaire to measure manual lateralization. Then, TMS recordings will be performed. Participants of the first experimental group will have their left arm immobilized for 8 hours. The second experimental group will undergo the tDCS protocol, aimed at inducing hypoexcitability. The third group will undergo a protocol using anodal tDCS (a-tDCS), to induce an increase in excitability. The control group will undergo a protocol Sham (no effect). TMS recordings will be perform once more to measure changes in excitability induced by immobilization and by tDCS. The task will then consist, for the four groups, of the execution of a maximum number of motor sequences, consisting of 5 keys to be pressed on a computer keyboard. Participants will perform 2 series of actual trials, then perform 15 series of mental training trials, followed by 2 series of actual movements. On Days 2 to 4, participants will complete 15 imagine trials, followed by 2 series of actual movements. On Day 5 of Week 1 as well as Day 1 of Week 2, the participants will perform 2 series of actual movements and TMS recordings will be manage.

Statistical design

For the behavioral data, statistical analysis will focus on duration, accuracy and error. The normality of dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or Mixed Linear Models with the Test (pre and post tests) as within-subject factor and Group as between-subject factor. Post hoc tests will allow for pairwise comparisons. If the data are not normally distributed, non-parametric tests will be used: generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.

For the neurophysiological data (recruitment curves), the mean amplitude of the motor evoked potentials will be calculated in order to obtain recruitment curves (pre-training, immediate and delayed post-training). The normality of the dependent variables will be evaluated by the Shapiro-Wilk test. If the data are normally distributed, parametric tests will be used: ANOVA or mixed linear models with the test (pre-training, post-training) as within-subject factor and the group as a between-subject factor. Post hoc tests will allow for pairwise comparisons If the data are not normally distributed, non-parametric tests will be used: generalized linear mixed models. Post hoc tests will allow for pairwise comparisons.