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Impact of a combined cognitive and response inhibition training in school-age children

Yesica Aydmune[1], Sebastián Lipina[2], María Fernanda López-Ramón[3,4], & Isabel Introzzi[1]
[1]Instituto de Psicología Básica, Aplicada y Tecnología - Universidad Nacional de Mar del Plata – Consejo Nacional de Investigaciones Científicas y Técnicas. Argentina
[2]Unidad de Neurobiología Aplicada, Centro de Educación Médica e Investigaciones Clínicas "Norberto Quirno" -Consejo Nacional de Investigaciones Científicas y Técnicas. Argentina
[3]Departamento de Psicología Evolutiva y de la Educación - Universidad de Valencia.
[4]Departamento de Psicología Experimental - Universidad de Granada, España.

Abstract
The aims of this work were: (1) to implement a brief 6 sessions intervention, which combines training activities of Cognitive Inhibition (CI) and Response Inhibition (RI), in a group of schoolchildren aged from 6 to 8 years ($M = 6.8$, $SD = .61$; $n = 38$; 60.5% girls, 39.5% boys); (2) to analyze the effects of the intervention on training tasks performances, on untraining inhibitory tasks (near transfer) and on performance in a FI task (far transfer); and (3) to study individual differences in training effects associated with baseline inhibitory performance. An experimental design, pre-test, post-test and control group (CG), was implemented. The main results indicate an improvement in performance in trained tasks -differences between first and last session: CI training $Z = -3.455$, p = .001; RI training $Z = -3.758$, $p < .001$-, low effects of the intervention on performance in an untrained CI task -experimental group (EG), difference pre/post-test performance: $F(1,16) = 3.893$, $p = .066$, $np2 = .196$- and effects on performance in the FI task -$F(1,36) = 6.484$, $p = .015$, $np2 = .153$. In the first two cases, it was observed that the students with a lower base line inhibitory performance, showed greater profits -CI training, $r = -.524$, $p = .031$; RI training, $r = -.470$, $p = .057$; untrained CI task, $r = .755$, $p = .001$. We discussed the transfer based processing on short interventions and the use of different tasks measurements.
Keywords: training; cognitive inhibition; response inhibition; transfer; school.

Resumen
Impacto de un entrenamiento combinado de inhibición cognitiva y de la respuesta en niños en edad escolar. Los objetivos de este trabajo fueron: (1) implementar una intervención breve de 6 sesiones, que combina actividades de entrenamiento de la inhibición cognitiva y de la respuesta, en un grupo de escolares de 6 a 8 años de edad ($M = 6.8$, $DE = .61$; $n = 38$; niñas = 60.5%, niños = 39.5%); (2) analizar los efectos de la intervención sobre el rendimiento en las tareas entrenadas, en tareas inhibitorias no entrenadas (transferencia cercana), y sobre el desempeño en una tarea de inteligencia fluida (transferencia lejana); y (3) estudiar las diferencias individuales en los efectos del entrenamiento asociadas con el rendimiento inhibitorio de base. Se implementó un diseño experimental con pre-test, post-test y grupo control. Los principales resultados indican un avance en el desempeño en las tareas de entrenamiento -diferencias entre primera y última sesión: entrenamiento de inhibición cognitiva, $Z = -3.455$, $p = .001$; entrenamiento de inhibición de la respuesta, $Z = -3.758$, $p < .001$- efectos bajos de la intervención sobre el desempeño en una tarea de inhibición cognitiva no entrenada – diferencias de rendimiento pre/post-test en el grupo experimental grupo experimental: $F(1,16) = 3.893$, $p = .066$, $np2 = .196$-, y efectos sobre el rendimiento en la tarea de inteligencia fluida - $F(1,36) = 6.484$, $p = .015$, $np2 = .153$. En los dos primeros casos se observó que los escolares con un rendimiento inhibitorio de base más bajo, presentaron mayores ganancias -entrenamiento de inhibición cognitiva, $r = -.524$, $p = .031$; entrenamiento de inhibición de la respuesta $r = -.470$, $p = .057$; tarea no entrenada de inhibición cognitiva, $r = .755$, $p = .001$. Se discute en torno a los alcances de la transferencia a partir de intervenciones breves y del empleo de distintas tareas de medición.
Palabras clave: entrenamiento; inhibición cognitiva; inhibición de la respuesta; transferencia; escolares.

Corresponding author:
Yesica Aydmune.
Instituto de Psicología Básica, Aplicada y Tecnología, Universidad Nacional de Mar del Plata – Consejo Nacional de Investigaciones Científicas y Técnicas.
Facultad de Psicología. Funes 3250, Cuerpo V, Nivel III, Mar del Plata, Argentina.
E-mail: yesicaaydmune@conicet.gov.ar

Introduction

Inhibition is considered one of the main Executive Functions –EF- (i.e., high-order cognitive processes involved in goal-oriented behavior), as it serves as a basis for the development and functioning of more complex processing (Diamond, 2013; Doebel, 2020; Friedman & Miyake, 2017). It is even suggested that inhibition could be serving as the fundamental basis for the rest of the EF (Hasher et al., 2007; Miyake & Friedman, 2012). Generally speaking, inhibition can be defined as the ability to limit proponent tendencies linked to emotion, thought, behavior and environmental stimuli that interfere with the achievement of personal goals (Diamond, 2013; Mann et al., 2013). In this sense, current models consider inhibition as a multidimensional construct, generally identifying three inhibitory processes: Perceptual Inhibition (PI), Cognitive Inhibition (CI) and Response Inhibition (RI) -terms may change according to the model/author (Friedman & Miyake, 2004; Introzzi et al., 2016). Briefly, PI refers to the ability to resist interference from external stimuli on the ongoing task; CI makes it possible to suppress prepotent mental representations that are irrelevant to the processing objectives; and the IR allows to stop motor actions that could be inappropriate for the context and the processing objectives (Diamond, 2013; Friedman & Miyake, 2004; Hasher et al., 2007; Tiego et al., 2018). Various studies suggest that inhibitory processes have specific developmental trajectories (Introzzi et al., 2016; Vadaga et al., 2015; Vuillier et al., 2016), although in general it can be said that they show important improvements in their functioning during childhood, in the years that correspond with the preschool and primary school stages (Introzzi et al., 2016). Inhibitory functioning in childhood is linked to the development and performance of more complex skills that are important for the daily performance of children. For example, different inhibitory processes have been linked to Fluid Intelligence -FI- (e.g., Aydmune, Introzzi, Zamora, & Stelzer, 2020; Michel & Anderson, 2009), the control of impulsive behaviors (e.g., Aydmune, Introzzi, Richard's et al., 2019; Volckaert & Noël, 2015), the comprehensive reading of texts (e.g., Borella et al., 2010; Borella & De Ribaupierre, 2014; Demagistri et al., 2012) and skills identified in the domain of arithmetic (Cragg et al., 2017; De Visscher & Noël, 2014; Robinson & Dubé, 2013).

Therefore, different authors have proposed to intervene on inhibition processing with the goal of knowing the plasticity of its functioning, and generate effects on other related skills (Baker et al., 2020; Diamond, 2012, 2013; Jolles & Crone, 2012; Karbach & Unger, 2014; Zelazo & Carlson, 2012). These interventions are so called inhibitory training (Baker et al., 2020) and although they take place throughout the life cycle, special emphasis has been placed on child labour because of the potential impact of higher levels of neural plasticity in early life (Karbach & Unger, 2014; Jolles & Crone, 2012). In this context, process-based training predominates, from which activities with a high requirement of processes to optimize are proposed (Jolles & Crone, 2012; Karbach & Unger, 2014; Rueda et al., 2016). Inhibitory training in children with typical development seeks to understand to what extent the functioning of inhibitory processes can be modified, promoting their progress reaching optimal levels according to the developmental stage in which they are (Jolles & Crone, 2012; Karbach & Unger, 2014), as well as other related skills (Diamond, 2012, 2013; Zelazo & Carlson, 2012).

However, with regard to this work, recent revisions pointed out several crucial issues. First, the set of interventions designed to specifically train inhibition is lower compared to other EF such as working memory (Karbach & Unger, 2014; Rueda et al., 2016). Secondly, some results are contradictory -for example, while in some cases effects are found after the intervention (Zhao et al., 2016), in others these effects are not observed (Thorell et al., 2009). These contradictory effects could be linked to multiple factors affecting training, such as individual differences in baseline inhibitory performance that is not frequently analyzed (Johann & Karbach, 2020). Third, not all studies address different inhibitory processes and what is called here CI, only recently has started to be targeted by a specific training (Aydmune et al., 2017; Aydmune, Introzzi, & Lipina, 2019; Aydmune et al., 2018). Within the framework of the latter work, computerized training tasks were developed to train in particular CI and RI in schoolchildren mainly on the first years of primary school were the tasks were managed through experimental designs, in the school context (Aydmune, Introzzi, & Lipina, 2019). The main results obtained indicated short-term effects on performance in a working memory task from CI and RI training; and short- and long-term effects on performance in a FI task after training in CI. The design implemented allowed to investigate the specific effects of each task; and qualitatively obtain information on the applicability of this type of intervention in school contexts.

However, the literature suggests that the more intensive interventions, which largely demand the processes that are intended to be optimized, can lead to greater changes (Diamond, 2012; Korzeniowski et al., 2017). However, it is also important to take into account the context in which the training is intended to be applied. To this aim, several researchers from school research area highlight the existence of factors that hinder the systematics of the training: suspension of classes, development of special activities proposed by the institution or the teacher, repeated absences of children due to travel or illness, etc. (Canet Juric et al., 2020). In this sense, a recent review reveals that the number of training sessions varies from study to study, finding an average of 14 sessions (SD = 9.13). Then, a question that still needs to be addressed is whether the reduction in the number of sessions, would optimize the training menus, or and at the same time decreases the eventual interference of the aforementioned factors.

For it, the objectives of this work are the following: (1) apply a short training that combines the demand for CI and RI tasks, in a group of schoolchildren from 6 to 8 years of age; (2) to analyze the effects of the aforementioned intervention on training tasks performances, on inhibitory tasks other than those trained (i.e., near transfer) and on performance in a FI task that is a more complex ability linked to inhibition (i.e., far transfer); and (3) to study individual differences in training effects associated with baseline inhibitory performance.

Consequently, we expected (hypothesis) to apply a short inhibitory training in the school context; to find improvements on training task performance; to observe near and far transfer effects; and to find individual differences in training effects associated with baseline inhibitory performance.

Method

Participants

We evaluated a sample of 38 schoolchildren (23 girls, 15 boys) from 6 to 8 years of age (M = 6.8, SD = .61) who were in the 1st, 2nd and 3rd grade of primary school, in a privately school from the city of Mar del Plata, Argentina (the calculation of the sample size is given under "statistical analysis"). For the participants inclusion on the sample, the following criteria were followed: non-recurrent students, who presented a typical development (i.e. without deficits or alterations, without a history of learning disorder or development), and with normal or corrected vision and hearing. The participants were part of one of two groups: EG was made up of 18 schoolchildren (10 girls, 8 boys; age *M* = 6.78, *SD* = .55) and CG for 26 participants (13 girls, 7 boys; age *M* = 6.85, *SD* = .67).

Instruments

Pre and post-test measurements

1. To measure CI, the *Proactive Interference Task -IP (*Aydmune, Introzzi, & Zamora, 2020) was used. The activity is based on the Brown-Peterson paradigm (Brown, 1958; Peterson & Peterson, 1959) and consists of two evaluation blocks of four trials each. Each trial consists of a list of four words, which are presented simultaneously in auditory (verbal label) and visual (drawing) form for 2 seconds. In each trial, the participant´s task was to pay attention to the list. Then, they must perform a brief distracting task for 16 seconds, to avoid review. Finally, participants were asked to recall as many words as possible from the list that was presented. The researcher recorded such words; while the stimuli run in a PowerPoint presentation.

In each block, the first three lists contained words of the same semantic category, while the last list contained words of a different category. This task assessed from each participant an Index of Susceptibility to Interference (ISI) that is obtained by subtracting the words correctly remembered from lists 2 and 3 to those of lists 1 and 4 in each block, and then obtaining an average value out of both. According to the scientific literature (e.g., Borella et al., 2010; Christ et al., 2011) worse execution is expected in lists 2 and 3, due to the interference effect generated by the words presented above -because they belong to the same semantic category. Thus, the greater the interference they show, the less efficient the process of resistance (CI). The task has adequate levels of reliability and validity (Aydmune et al., 2018; Aydmune, Introzzi, & Zamora, 2020).

2. To evaluate RI, a task based on the Simon paradigm (Simon & Rudell, 1967) was used, composed of two blocks of the *TAC battery Finger Task* (Introzzi & Canet Juric, 2012): Congruent (CB) and Incongruent (IB). Both blocks are composed of 32 trials, and start with a cross fixation in the center of the screen that remains throughout the task. The stimuli -hands with the index finger pointing- appear one at a time, on the left or right side of the cross, for 750ms. The CB is first administered and consists of matching assays, in which a hand with the index finger pointing straight down appears on the left or right side of the screen. The participant must press a key located on the same side (ipsilateral) in which the stimulus is located ("Z" when it appears on the left side, and "M" when it appears on the right). IB is administered second, and consists of incongruent trials. Here, the stimuli are hands with the index finger pointing to the opposite side. The participant must press a button on the side opposite the stimulus location ("M" if the stimulus is on the left side and "Z" if it is on the right). Various studies show that it responds more quickly and accurately, when concur the stimulus and the place where the response should be executed, sustaining the existence of a predominant tendency to respond on the same side in which the stimulus is presented. This trend is expected to be inhibited in IB through RI.

In the age range that we assesses on the present work, the accuracy index is more sensitive (Davidson et al., 2006; Traverso et al., 2018), so here as the main performance index will work with precision in the IB controlling the performance base in the CB. The task presents levels of validity and compliance with appropriate internal criteria for its application in children (Richard´s et al., 2017).

3. To measure FI, the *Progressive Matrix Test, Colored Scale* (Raven et al., 1993) was used. This test contains abstract material and consists of 36 problems of increasing difficulty. Each problem involves an incomplete colored drawing, with six small drawings below, of which only one allows it to be completed correctly according to a criterion to be abstracted. The participant should find and point it out. The punctuation for the correct answer and its sum corresponds to the main performance variable. The scale has Argentinian normative data and adequate reliability levels to be administered in children (Cayssials et al., 1993). In view of the above, the percentiles were considered in this paper.

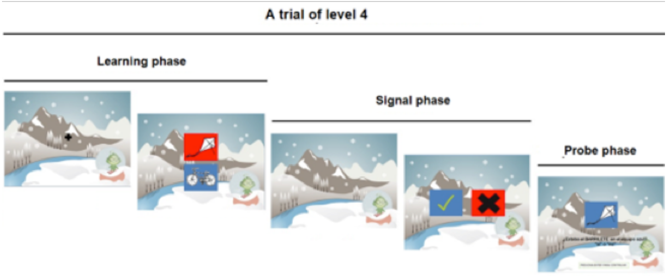
Training tasks

The tasks are adaptive (i.e., the level of difficulty is increased accordingly to the participants performance) and contain appropriate stimuli and rules for children aged from 6 to 8. A character called "Verdecito" presents the instructions and accompanies the participants during all the activities.

1. *CI training task*. This activity was designed on the basis of the experimental paradigm used by Oberauer (2001), which combines features of directed forgetting and proactive interference. Each trial is divided into three phases: learning, signal and probe. Learning phase, in which the participant is asked to remember two rows of stimuli, one on a red background and the other on a blue background. The lists involved words with equal length and different semantic categories (to avoid the interference in the recognition of the requested probe). The lists are presented for 1.3 seconds per stimulus. Secondly, the signal phase took place. It was shown a sign that informs the participants which of the two list should be remembered -as it will be relevant for a later recognition task- and which list should be forgotten -as it will be irrelevant later on. On the probe phase a test item was presented and the participant was asked to indicate whether or not the items were part of the relevant list by answering "yes" or "no" (see Figure 1). On the instructions, "Verdecito" explained that together with his friends they have formed two teams -red and blue- to play various games, but they have forgotten which team they belong to. Thus, "Verdecito" proposes the participant to help him find the team that belonged each of his friends. Verbal responses from participants are recorded by the researcher; while the activity runs on a PowerPoint document.

The probes are of three types: relevant, which are in the list which has to be remembered; irrelevant, which are in the list which has to be forgotten-; and new, which are not in either of the two lists. At the signal, the participant was asked to forget the irrelevant list (i.e. to inhibit it). If the participant fails to do it, an irrelevant probe, could be compared to the irrelevant list that has not been removed and considered as part of the relevant list. As a result, further errors are likely to be made in the trials with an irrelevant probe. Thus, the increase in the difficulty of the task was produced through two factors: (i) Reduction of time elapsed between the presentation of the signal and the presentation of the probe. Here, the interval was reduced by 300ms from one level to another. (ii) Increase of percentage of trails with irrelevant probes. Here, the percentage was progressively increasing from one level to another, from 30% to 60% of irrelevant probes (for more details see Aydmune, Introozzi, & Lipina, 2019). The activity consists of 6 levels of different complexity (each level contains blocks of 10 trials each).

Figure 1. Example of a trial of level 4 in cognitive inhibition training task

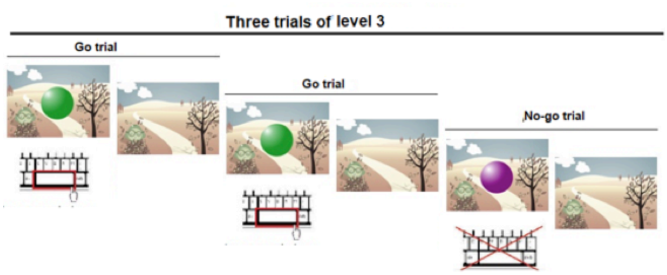


Note. Each trial is divided into three stages: learning, signal, and probe. In the learning phase, after the presentation of a fixation cross, the participant is requested to remember two lines of stimuli. In the signal phase (after a blank screen) it is shown a signal that informs which of the two lists will have to be remembered and which one will have to be forgotten. Finally, the probe phase takes place, where a stimulus is presented and the participant has to indicate if it was in the relevant list or not – saying "yes" or "no", respectively.

2. *RI training task*. The activity was built on the Go/no-go paradigm. On the computer screen were presented one at a time, stimuli -green and violet balls. Green balls were the go stimuli, to which the participant was asked to give an answer, pressing the space bar as fast as possible. Violet balls were non-go stimuli and participants were asked no to press any key on these cases (hold the answer). In go/no-go tasks, the go stimuli are presented more frequently, creating a tendency to respond on all trials (predominant response), which had to be inhibited in non-go trials (Bezdjian et al., 2014). On the instructions, "Verdecito" explains that he wants to assemble a "ball pool playground" containing only green balls (because it is his favorite color). The participants were asked to help "Verdecito" to achieve this aim by catching only balls of this color (see Figure 2).

The task difficulty increase was set by two factors: (i) The decrease in the time between stimuli (Lindqvist & Thorell, 2008) which favored the predominance of the response, and reduced the probability to inhibit a predominant behavior (Simpson et al., 2012). This interval was reduced 300ms from a lower level of difficulty to a higher level of difficulty, being 300ms the lowest possible (Zhao et al., 2016). (ii) The increase in the amount of go trials that precede the no-go, which increases the predominance of the response, making it more difficult for the participants to inhibit pressing the key on no-go trials (Durston et al., 2002). Six levels of difficulty were formed, each with blocks of 30 to 40 trials (for more details see Aydmune, Introzzi, & Lipina, 2019).

Figure 2. Example of three trial of level 3 in the response training task



Note. The go stimulus is "a green ball" in which the participant has to press the space bar on the computer keyboard, while the no-go stimulus is "a violet ball" in this case, he/she must not press any key.

Procedure and ethical considerations

The project was approved by the ethics committee of the National University of Mar del Plata and then by educational institutions of the city of Mar del Plata that agreed to participate on the research. Informed consent for participate in the study was obtained from children´s parents or legal representatives. Subjects were randomly assigned to one of two conditions: EG and CG. At the EG, participants worked with CI and RI training activities over 6 sessions, with a duration of 15-minute each, once a week. In the CG, students performed only at level 1 of the training tasks (number of sessions: M = 2.6, SD = 2.19); these conditions do not significantly demand inhibitory processes (Aydmune, Introzzi, & Lipina, 2019). Before and after going through these conditions, all children were evaluated with pre- and post-test measures. The tasks were administered by authors of this work and other project members accredited to do so; and took place in educational institutions schoolchildren attended, in a specially designed classroom for research purposes.

Statistical analysis

The calculation of the sample size was done through the *G*Power software,* based on the planned data analysis and taking into account the size of the groups in studies with similar objectives (for a review see Aydmune et al., 2017).

In order to analyze the effects of the intervention on the performance in the training tasks, on untrained inhibitory tasks (near transfer) and on the performance in a FI task (far transfer), the following analyses were planned: An ANOVA of a factor to evaluate the equivalence between the age groups and the main performance indices of the pre- and post-test measurement tasks. To analyze the progress during the training, we planned descriptive analyses and an analysis of differences in performance with respect to the level reached in the first and last session in each task, through the non-parametric test Wilcoxon (taking into account that level reached is an ordinal variable). All this, following the proposal of other works with similar objectives (Johann & Karbach, 2020). In order to analyze the effects of near and far transfer, we thought about the application of mixed ANOVAs, with an inter-subject factor (i.e., Group, with two categories: EG and CG) and an intra-subject factor (i.e., Time, referred to performance in CI task in one analysis, RI in a second analysis, and FI in a third analysis; in each case with two levels: pre and post-test). Both in the case of performance during training and in the analysis regarding the near and far transfer, the study of individual differences in training gains was considered both on in pre- and post-test measurement tasks. In this sense, partial correlations were planned (controlling age) between the baseline of each of the trainings with the gains of the training; pre-test performance and gains on each task (Johann & Karbach, 2020).

Results

First, on Table 1 we show descriptive statistics of the main performance values that were obtained in the pre- and post-test instances.

Analysis of the initial equivalence of the groups.

One factor ANOVA showed that the groups do not differ significantly with respect to age and the main rates of performance of pre- and post-test measurement tasks (ps>.095).

Table 2. Descriptives and comparations respect to the level reached in the first and last session in each training task.

CI training						RI training					
Differences first session - last session (level reached)		First sesión (level reached)	Last session (level reached)			Differences first session - last session (level reached)		First sesión (level reached)	Last session (level reached)		
Z*	p	Md	Md	min	max	Z*	p	Md	Md	min	max
-3.455	.001	1	3	1	5	-3.758	.000	1	2	1	3

*Note: CI = cognitive inhibition; RI = response inhibition; Md = median; min = minimum; max = maximum. *Wilcoxon test, signification level < .05*

Table 1. Descriptive statistics of the main performance values that were obtained in the pre- and post-test instances.

variables	EG		CG	
	Mean	Standard deviation	Mean	Standard deviation
ISI pre-test	2.79	1.46	2.05	1.18
ISI post-test	2.08	.99	1.9	1.15
IB pre-test	76.44	23.86	69.05	31.9
IB post-test	78.56	29.7	79.05	24.38
FI pre-test	51.11	29.13	55.5	29.01
FI post-test	63.83	29.01	54.45	31.9

Note: EG = experimental group. CG = control group. ISI = Index of Susceptibility to Interference. IB = Incongruent Block, accuracy. FI = Fluid intelligence, accuracy.

Training

Descriptive analyses show that all EG participants began performing at the first level of each task, and most completed their training at a higher level (17 cases with respect to the RI task and 15 in relation with the CI task). Wilcoxon test showed statistically significant differences with respect to the level reached in the first and last session in each training task (see Table 2).

Then, in order to analyze the individual differences regarding training gains, partial correlations (controlling age) were applied between the baseline of each of the trainings (i.e., performance in session 1 of CI training and performance in session 1 of RI training) with training gains (i.e., performance differences between the first and last session, in each training task). Regarding training in CI, a negative and significant correlation was found (r = -.524, p = .031) and for training in RI, a negative, marginally significant correlation (r = -.470, p = .057). Those who started with a lower performance, observed greater gains in their performance during training.

Near transfer

CI task (Interference Proactive Task)

First a mixed ANOVA was applied with an inter-subject factor (i.e., Group, with two categories: GE and GC) and an intra-subject factor (i.e., Time, referred to performance in the task, with two levels: pre and post-test). This analysis did not reveal effect of Time -$F(1,35)$ = 3.16, p = . 084, np2 = . 083-, of Group -$F(1,35)$ = 2.211, p = . 146, np2 = . 059-, or interaction Time x Group -$F(1,35)$ = 1,282, p = . 265, np2 = . 035. Descriptive statistics such as the mean of performance of both groups in pre- and post-test instances (Table 1) suggest a greater reduction of interference in EG. ANOVAs repeated measurements carried out for each group indicate for EG a marginally significant difference between their pre- and post-test performance -$F(1,16)$ = 3,893, p = .066, np2 = .196- and no difference in the case of CG -F(1,19) = .228, p = .639, *np2* = .012.

Considering the above, the EG (at intra-group level) was examined in order to study the individual differences with respect to the results found. We analyzed the correlations (controlling age) between performance in the pre-test and gains in the CI task (difference between performance in the pre and post-test). A positive and significant correlation was observed (r = .755, p = .001). In other words, those who had greater interference (due to less control by CI) showed greater gain from pre to post-test.

RI task (Simon task)

A mixed ANOVA with an inter-subject factor (Group) and an intra-subject factor (Time), did not reveal effect of Time -$F(1,35)$ = .4, p = .531, np2 = .011-, of Group -$F(1,35)$ = 2.693, p = .110, np2 = .071-, nor of interaction Time x Group -$F(1,35)$ = .668, p = .419, *np2* = .019. ANOVAs repeated measurements for each group do not reveal significant changes from pre to post-test (*ps*>.5 in both cases).

Far transfer

A mixed ANOVA was applied with an inter-subject factor (Group) and an intra-subject factor (Time). Time effect -$F(1,36)$ = 4,657, p = .038, *np2* = .115-, no Group effect -$F(1,36)$ = .72, p = .79, *np2* = .002-, was observed; and finally we found interaction effect Time x Group -$F(1,36)$ = 6.484, p = .015, *np2* = .153. To advance the understanding of this interaction effect, ANOVAs repeated measures were performed for each group. Analyses show that only EG significantly changes its performance from pre to post-test -$F(1,17)$ = 12.328, p = .003, *np2* = .420; CG, $F(1,19)$ = .070, p = .794, *np2* = .004. Descriptive statistics (Table 1) suggest that this performance improves from pre to post-test.

In view of the above, the EG was examined in order to study the individual differences in the results found. We analyzed the correlations (controlling age) between the performance in the pre-test in CI, RI and FI tasks, with the gains in the fluid intelligence task (difference between the performance in the pre and post-test). No significant relationships were observed (*ps*>.465).

Discussion

This work proposed to apply a brief and combined training of CI and RI in a group of schoolchildren aged 6 to 8; to analyze the effects of the intervention on the performance in training tasks; to study the effects of near and far transfer; and to analyze the individual differences related to the baseline performance.

Regarding the performance of the EG in the training tasks, the results indicate that in general the participants have managed to advance from the first level to others of greater difficulty, in both training tasks. Following what other authors have suggested, given that the training was adaptive, performance at increasing levels of difficulty suggest improvements in inhibitory performance (Johann & Karbach, 2020). Analysis of individual differences in baseline inhibitory performance in these training tasks suggests that those who started with a lower performance observed higher gains in their performance during training (and vice versa). There could be some form of compensation that would tend to level the playing field, as stated in the literature on inhibitory and executive training in general (e.g., Johann & Karbach, 2020; Traverso et al., 2015; Volckaert & Noël, 2015).

Regarding the effects of near transfer of training, initial analysis revealed no effects on performance in untrained tasks of CI and RI. A subsequent analysis indicated a (marginal) change by the EG from pre to post-test in its performance in the CI task. Specifically, it was observed that the ISI decreased. It is understood that the higher this index, the greater the proactive interference generated by the task and therefore the lower the performance of CI, since it is the process responsible for controlling it (Borella et al., 2013; Christ et al., 2011). Therefore, training may have contributed to some extent to CI performance and to the control it exerts over proactive interference. This is in line with what was mentioned in the previous paragraph about possible improvements in inhibitory processes (in this case related specifically with CI) throughout training, and with the results of some studies in which low effects of the intervention on this process have been found (Aydmune et al., 2018). Again, here a tendency to compensation was observed, in which participants with a lower performance baseline in the CI measurement task, could get greater gains in the post-test. It is worth noting that such results are low and that no effects on response inhibition were found. Perhaps the use of various tasks to measure inhibitory processes allows to control the impurity of the same (Friedman & Miyake, 2004) and to capture mayor changes, obtaining more information about the scope and limits of the transfer.

It should be noted that in this study non-training task were used to contribute to a greater extent with the understanding of the transfer. Tasks identical to those of training are used in several previous studies (e.g., Dowsett & Lievesey, 2000; Johann & Karbach, 2020; Liu et al., 2015; Zhao et al., 2016) but the use of tasks based on a single experimental paradigm in both evaluation and training phases makes it difficult to analyze the near transfer. Conversely, the use of different tasks that involving the same type of cognitive process, allowed us to rule out that the observed improvements merely reflect the effects of the practice, rather than a strengthening of the trained component (Rapport et al., 2013; Traverso et al., 2015).

In turn, the number of sessions may not have been sufficient to generate observable effects. However, they would allow to observe effects of far transfer on performance in a FI task. The latter agree with the results of various studies in which benefits on FI were found after inhibitory training and which add evidence on the relationship of inhibition with FI during childhood (e.g., Aydmune, Introzzi, & Lipina, 2019; Liu et al., 2015; Zhao et al., 2016). However, this work also showed that a short training of 6 sessions is enough to generate such changes, and that they are independent of the performance of inhibitory baseline and even of FI.

Among other limitations already mentioned, such as the measures of inhibitory processes, it is worth noting that we evaluated a small and non-probabilistic sample. This aspect made it difficult to generalize the results, so future research should focus also on different socio-cultural contexts samples.

Future studies should deepen on the research of the role of individual differences in the intervention effects by considering other variables in addition to baseline performance. The analyses done on the present work suggest that the training would not work in the same way on all the functions assessed or on all subjects. Understanding which factors optimize or hinder an intervention is critical (Johann & Karbach, 2020); by considering both individual and environmental aspects, and also multiple factors that could intervene on modulating the development and executive functioning (Diamond, 2012; Canet Juric et al., 2020; Zelazo & Carlson, 2012).

In summary, the paper provides information on the applicability of a short inhibitory training in the school context and the effects that can be found in a group of 6- to 8-year-olds. Suggests that it is possible to optimize in some way certain functions such as inhibition and FI, which are essential for daily performance at this stage of life, for example, in terms of school performance (Aydmune, Introzzi, Zamora, & Stelzer, 2020; Borella et al., 2010; Cragg et al., 2017). It is therefore important to deepen our knowledge about the plasticity of these processes and the possibility of generating an impact on other important skills during childhood, both in the short and long term.

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