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Bridging the gap between the lab and the classroom: An online citizen science project with teachers aiming at improving inhibitory control of school-age children.

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Abstract

Online citizen science allows to bridge the gap between researchers and non-researchers and to improve scientific literacy of non-researchers. The aim of the present study was to determine whether a 5-week randomized control trial conducted by the teachers in their classroom could improve 6 to 12-year-old children's inhibitory control (IC). As expected, children in the IC training group improved their IC efficiency to a greater extent than children in the control training group. We provided the first evidence that such online science project can be effective to improve children's IC abilities and bridge the gap between the lab and the classroom.

Keywords: Citizen science, inhibitory control, classroom activities, training, children

Introduction

Using neuroscience to improve education has been debated for the last 15 years or so with some researchers arguing that neuroscience and education could be a bridge too far (Bowers, 2016) while others seeing more promise into the emerging field of neuroscience and education (e.g., Ansari, De Smedt, & Grabner, 2012). Thus far, most of the debate has been focused on whether new insights on how the brain functions can improve teaching and educational practice but less so on how to effectively bridge the gap between the lab and the classroom.

One fruitful way to bridge the gap between the two communities is to have non-researchers to participate in scientific projects. In citizen or participatory science, researchers and non-researchers collaborate on a project. There are different types of participatory science projects with different levels of participation of non-researchers: at the minimum non-researchers are involved in data collection but in some projects non-researchers also define the problematic and design the materials and the method to be used in the study, together with the researchers (community or co-created projects). Participatory science is not a new phenomenon especially in scientific domains in which collection of large amount of data is needed such as in ecology, botany or astronomy (Miller-Rushing, Primack, & Bonney, 2012). The number of citizen science projects have grown exponentially due to the advent and proliferation of internet-based platforms, which can dramatically boost project's visibility, functionality and accessibility (Bonney et al., 2014). Participatory science not only allows to bridge the gap between researchers and non-researchers but also has the potential of improving scientific literacy of non-researchers especially in co-created projects (Bonney, Philips, Ballard, & Enck, 2015).

Surprisingly, to our knowledge there is no co-created participatory science project involving teachers adopting a randomized control trial (RCT) method to evaluate the effect of

specific classroom intervention on children's abilities. The aim of the present study was to do so by having 48 teachers conducting a RCT in their classroom consisting of a 5-week intervention focusing on improving inhibitory control abilities of 6 to 12 years of age children throughout classroom activities. We focused on inhibitory control (IC, i.e., the ability to resist automatisms, temptations, distractions, or interference and to adapt to conflicting situations, Diamond, 2013) for three main reasons. First, IC is at the root of the development of complex skills and more generally of cognitive development (Borst, Aïte, & Houdé, 2015). Second, IC abilities in childhood predict later academic and professional success (Moffitt et al., 2011). Third, dedicated playground (Zhao, Chen, Fu & Maes, 2015) and classroom activities (Diamond, Barnett, Thomas & Munro, 2007) can improve children's executive control and inhibitory control (*but see* e.g., Talanow & Ettinger, 2018; for studies reporting no effect of IC training).

Teachers volunteered to participate via a dedicated digital platform, www.lea.fr - Nathan[®]. Teachers co-constructed the study with the researchers, collected data on the pre- and post-test sessions. Furthermore, teachers randomly assigned, in each classroom, children to the IC training or control training group (to control for potential teacher effects, Nye, Konstantopoulos & Hedges, 2004). Critically, teachers also designed and ran the daily classroom activities that were part of the training. Specifically, teachers and researchers designed two versions of the classroom activities, one involving IC and another that did not. School-age children from grade 1 to grade 5 performed collectively a paper-and-pencil adaptation of the Color-Word Stroop task in the pre- and post-training sessions. In line with studies showing that executive functions and IC abilities in particular can be improved with classroom and playground activities (Diamond et al., 2007; Zhao et al., 2015), we expected children in the IC training group to improve their performance in the incongruent Stroop items

from pre- to post-training sessions to a greater extent than children from the control group, who received a different training.

Method

Participants

We recruited 1185 children from 6 to 12 years of age. A total of 136 children were excluded from the study because they performed only the pre or the post-training sessions. Thus, we analyzed the data of 1049 children: 161 2nd graders (81 boys, 7.6 ± 0.3 years), 143 3rd graders (80 boys, 8.7 ± 0.4 years), 321 4th graders (172 boys, 9.7 ± 0.4 years) and 424 5th graders (212 boys, 10.6 ± 0.4 years). Children of each class were randomly assigned to one of two groups: CI training group (N = 525; M = 9.6 ± 1.13 years of age, 251 girls) or control (N = 524; M = 9.6 ± 1.12 years of age, 253 girls) group. The study was carried out in accordance with national and international norms that govern the use of human research participants.

Material and procedure

Teachers (N=48) were recruited via a digital pedagogic community of teachers: www.lea.fr. We used the platform to recruit teachers, to define the aims of the project and the hypotheses, to train teachers on the RCT methodology, to design and upload the materials used for the classroom activities and the pre- and post-training session, and to garner the data collected by the teachers on the pre and post-training sessions.

Pre- and post-tests sessions. In the pre and post-test sessions, children' IC abilities were assessed by their teachers in their classroom with a paper-and-pencil adaptation of the Color-Word Stroop task (Stroop, 1935). In part A, words were congruent with the color ink (*i.e.* 'Red'

written in red). In part B, words were incongruent with the color ink (*i.e.* ‘Red’ written in blue). Children were required to identify the ink color of the word, as quickly and as accurately as possible by writing the initial of the color ink (‘R’ for ‘red’, ‘G’ for ‘green’, ‘B’ for ‘blue’ and ‘Y’ for ‘yellow’) on a response sheet. Each part was composed of 80 items. Children had 40 seconds to complete as many items as possible. Each part was preceded by 8 training items. All children completed Part A before Part B. Teachers collected the number of correct responses for each of the two parts and send those to the researchers.

Training Sessions. Ten minutes training sessions occurred 4 days per week for 5 weeks. A total of 9 classroom activities were designed, together with the teachers, to be performed collectively in each of the two training groups. Two versions of each activity were created: one that required to inhibit a prepotent response (performed by the IC training group) and one that did not (performed by the control training group). Teachers trained each group in their classroom: when one group was trained, the other group participated in a different school activity in autonomy. In the IC training group, activities were designed to train different types of inhibitory control processes from motor response to stimulus (or information) inhibition. For instance, in one of the motor response inhibition activities children played “Wesley says”. Children in the IC training group had to perform the action described by the teacher (such as clapping their hands) only if preceded by “Wesley says”. Children in the control training group had to perform the same actions but the teachers always introduced them with “Wesley says”. In one of the information inhibition task, children played a vocabulary game. Teachers presented an image of an object. Children in the control training were asked to name the object displayed on the image as quickly as possible. Children in the IC training group were asked to provide the name of a different object starting with the same letter as the object displayed on the image.

Results

To determine the effect of the IC training on IC abilities of children, we conducted a 2 (Part: A vs B) x 2 (Time: pre- vs. post-test sessions) x 2 (Training group: IC vs. control) analyses of variance (ANOVA) on the number of correct responses in the Color-Word Stroop task.

The ANOVA revealed a significant three-way interaction between Part, Time and Training group, $[F(1, 1047) = 10.49, p = .001, \eta^2_p = .01]$. Importantly, children in the IC training group had smaller interference scores (i.e., difference in number of correct responses between Part A and B) and thus better IC abilities than children in the control training group on the post-test session, $[F(1, 1047) = 11.4, p < .001, \eta^2_p = .01]$, while we found no difference between the two groups on the pre-test, $F < 1$ (see Figure 1). In addition, while the interference scores of the children in the IC training group decreased between the pre- and the post-test sessions, $[F(1, 524) = 18.04, p < .001, \eta^2_p = .03]$, the interference scores of the children in the control training group did not change between sessions, $F < 1$.

Discussion

The aim of the current study was twofold: (a) to measure the effect of a 5-week IC training intervention in the classroom on IC abilities of 6 to 12-year-old children and (b) to provide a proof a concept that a citizen science project taking the form of a RCT can provide meaningful results. As expected, we found that children engaged for 5 weeks in classroom activities involving IC improved to a greater extent their IC abilities as compared to children engaged in classroom activities in which IC was not involved. Importantly, the data collected on the pre- and post-training sessions, the random assignment of the children in the two training groups, and the training were performed by the teachers. Thus, the results of the present studies replicate the ones reported in previous studies (e.g., Diamond et al., 2007; Zhao et al., 2015)

but with teachers being involve in all part of the project. Thus, our study provides the first evidence that teachers can become experimenters in their own classroom adopting the experimental methodology classically used by researchers in the lab.

Embracing the role of an experimenter in the classroom is complicated for a teacher because it requires teachers to adopt a neutral attitude during the testing sessions and the random assignment of the children to the training groups which goes against their natural inclination to help children with academic difficulties (Yuen, Westwood & Wong, 2005). Teachers can be typically tempted to privilege these children by assigning them to the experimental group so that they could benefit from the intervention. Yet, our results show that there was no difference on performance of the children assigned to the IC and the ones assigned to the control group on the pre-test session, suggesting that teachers were not biased in the assignment of the children to the training groups.

Taken together, our findings provide the first evidence that online citizen science can be conducted in the classroom to address problematics of interest for both the researchers and the teachers using the experimental method in an ecological context without a direct intervention of the researchers. Importantly, conducting online citizen science with teachers could prevent the diffusion of weak or outdated scientific evidence which contribute to the diffusion of neuromyths in the teaching community (Howard Jones, 2014) by improving the communication and collaboration between researchers and teachers.

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Figure captions

Figure 1. Interference score on the pre- and post-training test in the control and IC training group. Error bars indicate standard error of the mean. $*p < .001$.

Figure 1. Interference score on the pre- and post-training test in the control and IC training group. Error bars depict the standard error of the mean. $*p < .001$.