

# Executive functions development in preschoolers from different socioeconomic backgrounds in Uruguay

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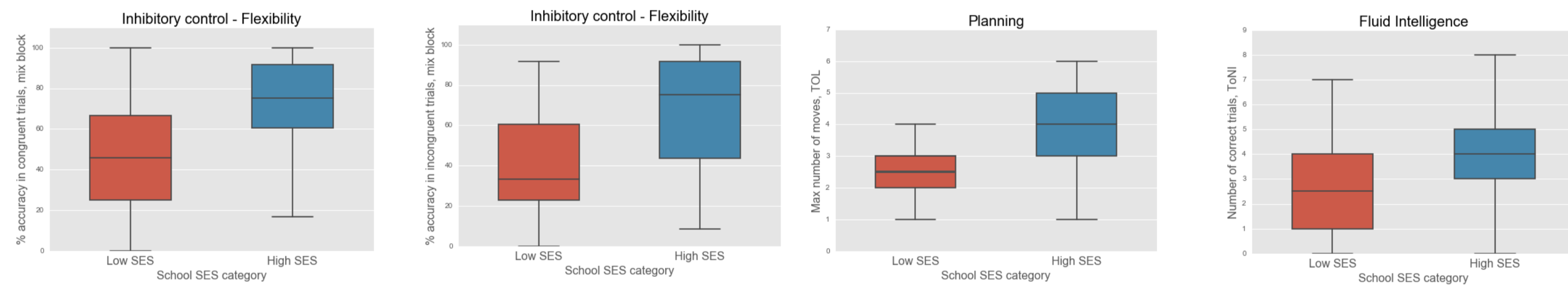
## 1 Introduction

Twenty percent of Uruguayan children grow up in poverty. Despite overwhelming evidence that links low socioeconomic status (SES) to poor academic achievement (1), the developmental trajectories of preschoolers that develop in impoverished contexts has not been quantitatively evaluated in our country. In addition, it has been shown that some short computer-based and traditional games interventions aimed at training cognitive processes are effective in children (2-6), although not all have shown consistent transfer to untrained processes (5,7). In Uruguay, the plan Ceibal provides tablets to all schools with elementary education. In the present project we have partnered with the developers of the gaming platform MateMarote (<https://www.facebook.com/MateMaroteOK/>) to study the effect of SES on the development of basic cognitive processes, and the impact of a short stimulation intervention in 5 year-old preschoolers. We show that SES has a deep impact in some basic executive functions (EF), such as cognitive control and flexibility, and higher order EFs, such as planning, and fluid intelligence. Working memory does not show a strong correlation with SES, and mental rotation of images is similar in all SES levels. An intervention with MateMarote for 8 weeks improves performance in two of the most affected functions: cognitive control and flexibility.

## 2 Results: SES and EFs

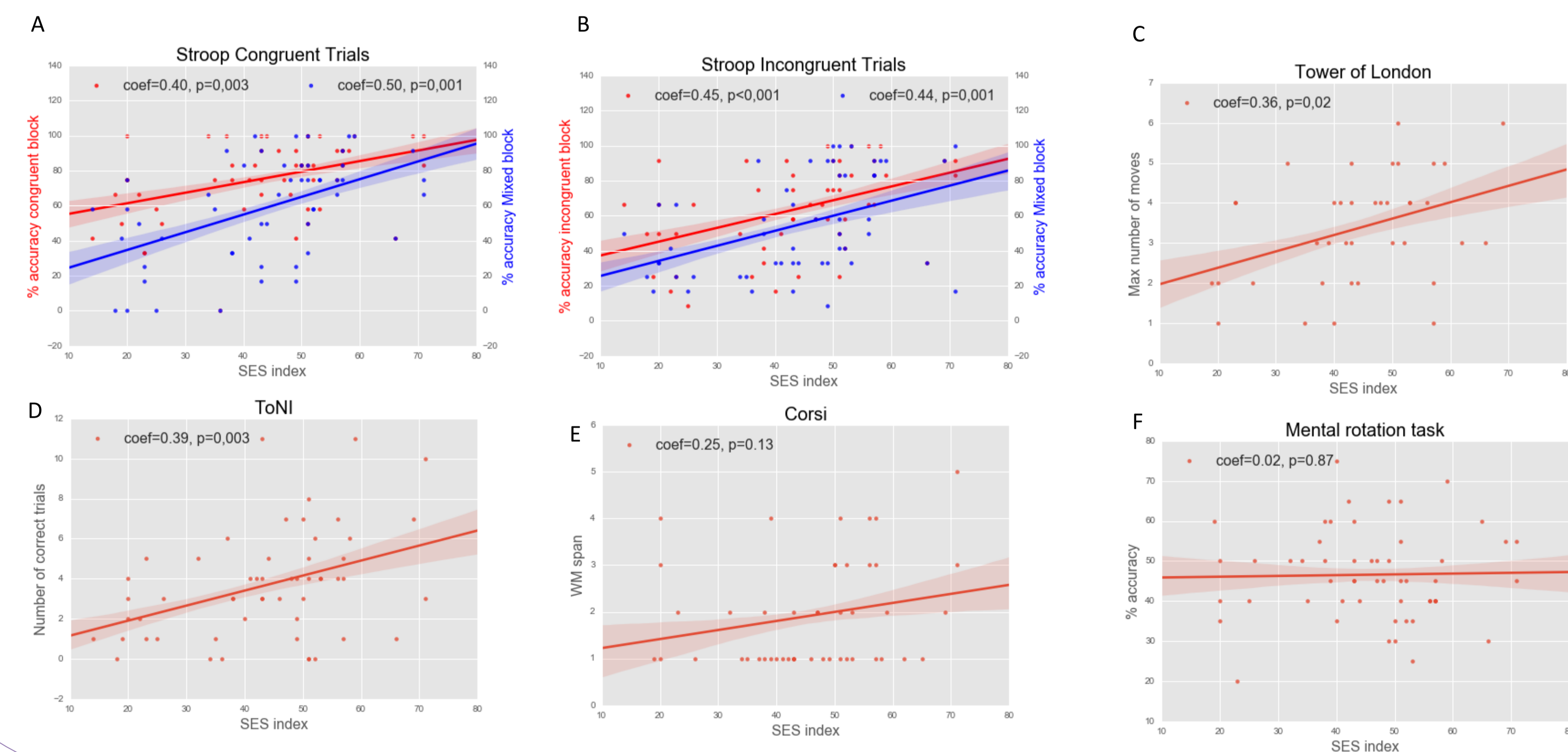
### How different are schools from low and high SES neighborhoods?

Very different. Performance in tasks that involve inhibitory control and cognitive flexibility (measured with a nonverbal Stroop task (10)), planning (assessed with ToL) and fluid intelligence (assessed with ToNI) are significantly lower in the schools from poor areas. The Mann-Whitney test p value is < 0.01 for all the tasks shown below.



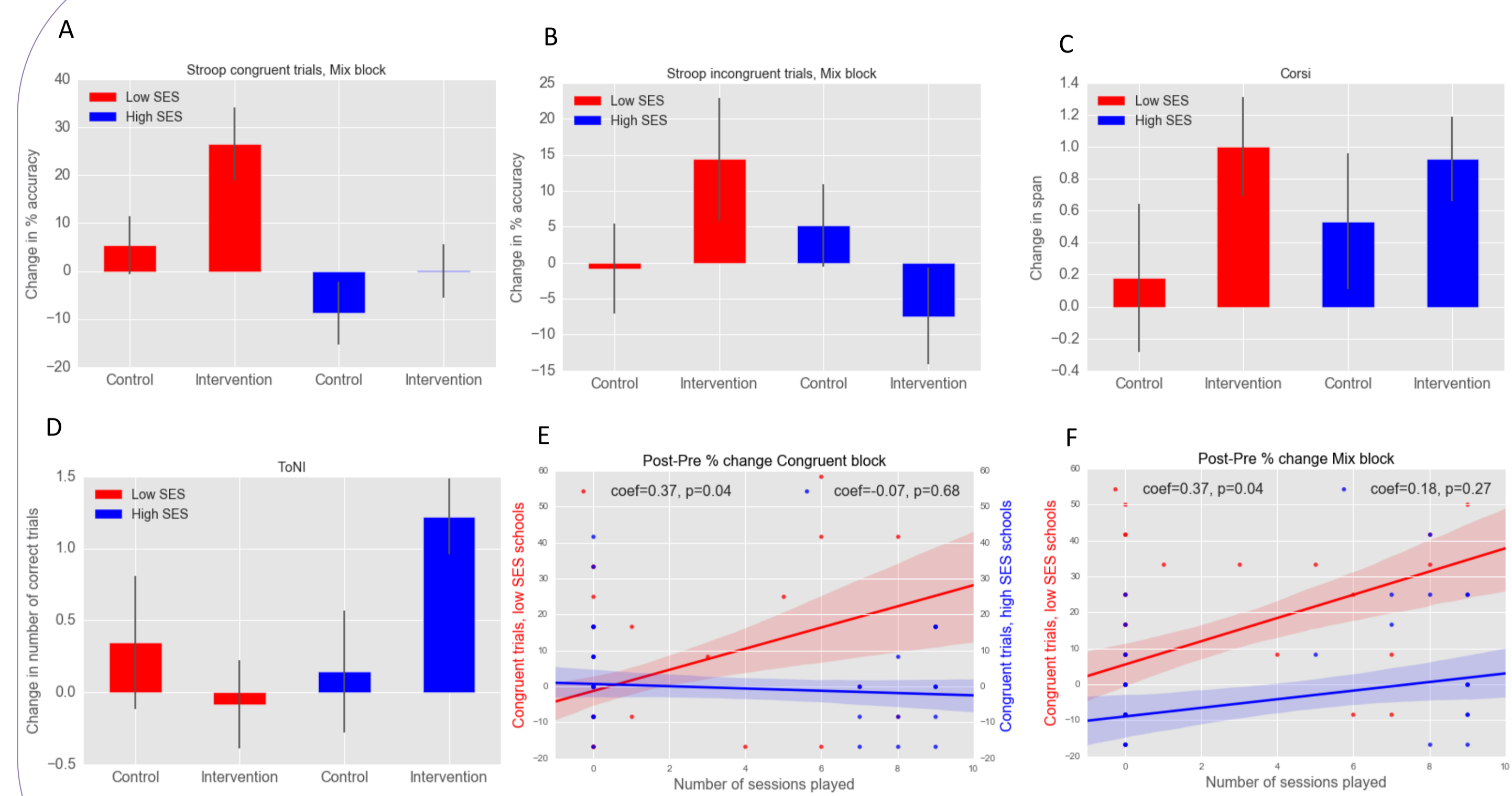
### Does socioeconomic status affect all executive functions in a similar way?

No. As can be seen in figures A-D, performance in the nonverbal Stroop task, Tower of London (ToL) and Test of nonverbal intelligence (ToNI) correlates strongly with SES level. However, performance in Corsi and in a mental rotation task do not correlate with SES.



## 3 Results: Intervention with MateMarote

### Was the intervention effective in the short term?



Figures A to D show the difference in performance (post measures – pre measures) for cognitive control/flexibility, working memory span, and fluid intelligence tasks. Repeated measures ANOVAs were ran with School SES category (Low and High SES) and experimental group (control or Intervention) as intersubject factors and intervention (Pre, Post) measures as intrasubject factor. For the congruent trials in the mixed block of Stroop, there was a significant interaction between intervention and school SES category ( $F=5.071$ ,  $p=.028$ ), and between intervention and experimental group ( $F=9.4$ ,  $p=.003$ ). For the incongruent trials, there was a significant interaction between intervention, experimental group and school SES category ( $F=4.094$ ,  $p=.047$ ). Figures E, F show the correlation between the change in performance and the amount of sessions played with “Avioncitos” (see design for games description). So far, we have not found significant effect of the intervention on the other tasks.

## 4 Design

### Low / High SES schools

Pre intervention measures: spatial WM, inhibitory control/flexibility, planning, general intelligence, mental rotation, CHAOS, BRIEF-P.

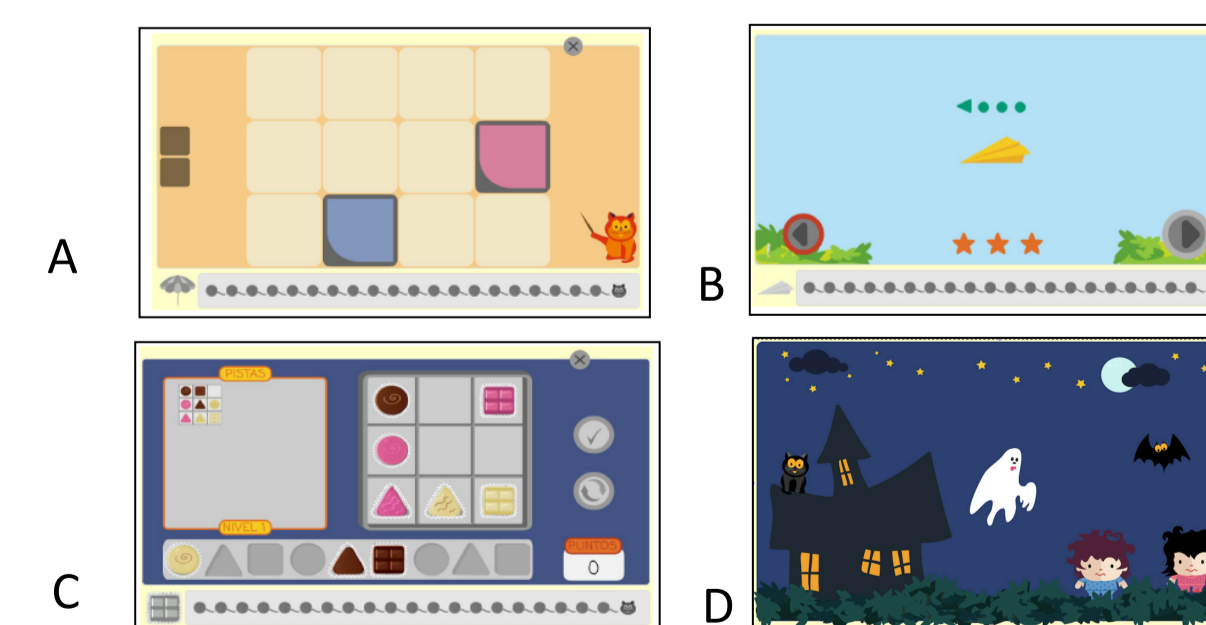
Active Control: three times per week for 8 weeks with preloaded apps

Intervention: three times per week for 8 weeks with MateMarote

Post intervention measures: spatial WM, inhibitory control/flexibility, planning, general intelligence, mental rotation, socioeconomic level, CHAOS, BRIEF-P.

The mentioned cognitive domains were assessed with the following game-like tasks: Corsi, heart-flower like Stroop (10) Tower of London, Test of Nonverbal Intelligence (ToNI), and a mental rotation task (8). During the intervention, children played with 4 games approximately 70 minutes each, distributed in 10 sessions of 7 minutes per game.

Below, representative screenshots of each game are shown. A- Memomarote, WM game, B- Avioncitos, Inhibitory control/ cognitive flexibility game, C- Chocolate Fix, reasoning game (8) and D- Ghosts, mental rotation game (9)



## 5 Discussion

- We show here the preliminary analysis of data collected on 100 5-year old preschoolers from 4 schools in the capital city of Uruguay.
- Our results underscores the profound effect of SES in the development of EFs. However, not all functions are affected at the same level: cognitive control/flexibility, planning and fluid intelligence are the most affected.
- Not shown here, the analysis of the BRIEF-P scale (that measures EFs in the classroom) completed by teachers the also show a deep impact of SES in ecological measures of EFs.
- We have also collected data on health, cognitive stimulation at home and level of organization at home (with the CHAOS scale). We plan to use these to explore possible mediating mechanisms that link SES to EF development.
- The intervention seems to be effective in training cognitive control and flexibility for children that attend schools categorized as low SES. The number of sessions played with the game that trains these processes correlates with the improvement for the kids in schools from poor areas.
- The lack of effect on the other cognitive processes should be interpreted with caution, given the small amount of children that participated in each group. Moreover, an analysis of individual differences in the way the kids played may shed light on the requirements for the intervention to be effective.
- For the future, we plan to increase the number of the sample, and add EEG coherence and frequency analysis measures to explore the neural correlates in the pre and post sessions.

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