The role of executive functions in kindergarteners' persistent and non-persistent behaviour

Niamh Oeri, Sonja Kälin, David Buttelmann

University of Bern

Author affiliations:

Department of Developmental Psychology, Institute of Psychology, University of Bern

Fabrikstrasse 8, CH-3012 Bern

Corresponding author:

Niamh Oeri

University of Bern

Institute of Psychology

Fabrikstrasse 8

CH-3012 Bern

Switzerland

Email: niamh.oeri@psy.unibe.ch

Abstract

The aim of the study was to examine if cognitive skills are related to persistence. Thus, children's (*N*= 157, mean age 5.9 years) persistent and non-persistent behaviours (i.e. cheating and off-task) were assessed in an unsolvable task. Additionally, we assessed children's executive functions and temperament. Analysis for persistence showed that cognitive inhibition and cognitive flexibility predicted children's persistent behaviour, beyond age and temperament. Analyses for non-persistent behaviours revealed that temperament and weak executive functions predicted cheating, while age predicted off-task behaviour.

Some children persist in the face of a challenge, others do not. Why this might be, is largely unknown. The aim of the present study was to approach this question by (a) examining factors possibly related to persistence and (b) examining non-persistent behaviours in relation to persistence. So far, persistence has been conceptualized as a temperamentally based sub-dimension of self-regulation (Rothbart, Ahadi, Hershey, & Fisher, 2001). Although separate lines of evidence favour the hypothesis that also cognitive skills could be related to persistence (see e.g. Barkley, 1997; Cuevas & Bell, 2014; Zelazo, 2015), no study has systematically analysed if executive functions (EF), i.e. inhibition, shifting and working memory (Miyake et al., 2000) were related to persistence. Without questioning the temperamental aspect of persistence, we aimed to examine a possible relation between EF and persistence.

During the persistence task, the puzzle-box task (Eisenberg et al., 1996), most children show persistence as well as non-persistent behaviours. However, non-persistent behaviours such as cheating and off-task are usually ignored. Therefore, we examined non-persistent behaviours in relation to persistence to understand persistence in its entity. Cheating refers to behaviour that serves task completion *but* deviates from the task rules, whereas off-task does not serve task completion. We define these three behaviours as mutually exclusive behavioural states. While this distinction is theoretical, qualitative differences need to be examined.

We expected temperament (i.e., effortful control), age and EF, inhibition in particular, to be related to persistence. For the EF components cognitive flexibility and working memory we did not have precise hypotheses regarding their relation to persistence. For the non-persistent behaviours cheating and off-task behaviour, we expected qualitative differences to be reflected in empirical data. Such differences between the behaviours should be reflected in their statistical independence. Furthermore, we assumed a negative relation between

inhibition and cheating and no relation between off-task behaviour and EF. We did not have precise hypotheses how temperament and non-persistent behaviours would be related.

Method

Participants

The final sample consisted of 157 kindergarteners (mean age: 69 months; 48% female) from predominantly middle-class families. Parents gave written consent before testing. The ethics committee approved the study (Approval No. 2017-04-00006). Data of 13 additional participants were excluded from the analysis as children noticed the camera during task (*n*=5) or were identified as outliers (*n* = 8).

Materials and Procedure

Puzzle Box

Persistent and non-persistent behaviours were assessed with the puzzle-box task (details see Eisenberg et al., 1996). Participants had to assemble a wooden puzzle placed in a box (60cm x 30cm x 35cm) with a curtain covering the front. After task instruction, the experimenter left the room for five minutes or until the child called her back in. The child`s persistence/cheating/off-task behaviour were recorded with two hidden cameras. Accumulated time spent in each behavioural state was divided by the total task-time. Final scores were percentages of time spent in every (mutually exclusive) behavioural state. A naïve coder coded half of the videos to warrant coding reliability. Interrater reliability was very high (ICC = .99) for all behaviours.

Executive Functions

EFs were assessed with individual EF-tasks (for methodological details please see Author, Year). Inhibition was assessed with two tablet-based tasks; an adapted version of the *Fruit-Stroop task* (Archibald & Kerns, 1999) and an adapted *Flanker task* (Eriksen & Eriksen, 1974). The Fruit-Stroop task consisted of three blocks (i.e., baseline, congruent, and incongruent), the Flanker task contained two blocks (i.e., congruent, and mixed). For both

tasks, the dependent variable was the number of correct responses in the incongruent condition.

Working memory skills were assessed with the *backwards colour-span task* (Zoelch, Seitz, & Schumann-Hengsteler, 2005). The dependent variable was the total number of correctly recalled sequences.

Cognitive flexibility was measured with a modified *dimensional-change card-sorting task* (Carlson, 2005) that included three conditions. Performance in the rule switching condition was used to calculate the dependent variable: ((errors + 1) x reaction time). Lower scores indicate better performance.

Temperament

Temperament was assessed with the very short form of the Children's Behavior Questionnaire (CBQ; German translation; Putnam & Rothbart, 2006). The questionnaire captures three temperamental dimensions: negative affect, effortful control, surgency. Higher scores on a temperamental dimension represent stronger manifestations.

Design

Children participated individually in two sessions (order counterbalanced between participants and gender).

Statistical analysis

For data-analysis, we used Jamovi 0.9.0.5. running on R (R Development Core Team, 2008, Jamovi project, 2018). For the Fruit-Stroop and the Flanker task, inter- and intraindividual reaction times below and above three standard deviations (SD) as well as reactions times below 150 ms were considered outliers and therefore excluded (2% of all trials). For all dependent variables, scores higher or lower than three SD from the sample's mean were considered as outliers and thus excluded (4.8% of the sample). The two inhibition tasks were combined to a joint inhibition-accuracy score. Table 1 provides descriptive data for all variables.

No gender differences were found for any of the puzzle-box variables: Persistence F (1, 153) < 1, p = 0.94, cheating F (1, 153) < 1, p = 0.69 or off-task F (1, 153) < 1, p = 0.41. Consequently, data was collapsed across gender.

Results

Intercorrelations among all variables are presented in Table 2. To examine the most parsimonious model, only variables significantly related to the particular behavioural state at the zero-order level were entered in the regression analyses (see Table 3). The analysis for persistence revealed that, beyond age and temperament, inhibition and cognitive flexibility explained 9% of the variance. The beta values suggested that better inhibitory skills and better cognitive flexibility predicted longer periods of persistence.

Separate regression analyses were run for the non-persistent behaviours. For cheating, beyond age and temperament, inhibition and cognitive flexibility explained 7% of the variance. The beta values indicated that weak inhibition skills and weak cognitive flexibility predicted longer periods of cheating. Off-task was age-related, but independent of temperament and EF.

Discussion

The results showed that not only temperamental factors (McCall, 1995; Rothbart et al., 2001) but also cognitive skills are related to persistence. While children with better inhibitory skills and better cognitive flexibility were more persistent, the reverse was found for cheating. Off-task, however, seems mainly age-related.

The present study is the first to systematically analyse children's non-persistent behaviours in relation to persistence. A remarkably high negative relation between persistence and cheating was found. Although this may be partly due to the interdependency between the behaviours, further factors might contribute to the opposing relation. Firstly, persistence and cheating differ fundamentally in preparedness to face task challenge and follow task rules. Secondly, contrary to cheating, persistent children are determined to solve the task, despite

very little to no reward. Hence, the behaviours differ fundamentally regarding reward in task achievement or task completion. Thus, analysing cheating in relation to persistence emphasises the importance of the particular manifestation of the cognitive skills related to persistence.

To rule out additional variables explaining the link between persistence and EF future studies should include variables such as motivation or compliance. Furthermore, a longitudinal design would be useful to examine the persistence-EF relation more thoroughly.

The current results suggest that the manifestation of surgency and that of inhibition and cognitive flexibility contribute to why some children persist in the face of a challenge while others do not. The present research also shows that studying all behaviours occurring during task assessment is a valuable approach to gain a more profound understanding of persistence.

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Tables

Table 1.

Descriptive statistics

	Mean	SD	Min	Max.
Age (months)	69.5	7.79	51	88
EF				
Inhibition[a]	69	.19	0	1
Working memory[b]	8.08	3.97	0	17
Cognitive flexibility[c]	326	219	47	1,008
Temperament				
Surgency	4.44	.83	2.08	6.17
Negative affect	3.84	.92	1.83	6.33
Effortful control	5.35	.65	3.5	6.83
Puzzle-box task (time in %)				
Persistence	61	29	0	100
Cheating	30	26	0	95
Off-task	9	10	0	44

Note. $N = 157$. [a] Accuracy score in %. [b] Sum score of correctly recalled sequences. [c] Combined score including reaction time and accuracy performance.

Table 2.

Intercorrelations among EF, temperament and behavioural states

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age (months) (1)									
EF									
Inhibition (2)	.34***								
Working memory (3)	.39***	.39***							
Cognitive flexibility (4)	-.35***	-.39***	-.32***						
Temperament									
Surgency (5)	-.04	-.13	-.05	0.14					
Negative affect (6)	.17*	-.07	.06	-.05	-.19*				
Effortful control (7)	.00	.11	.15	-.07	-.20*	-.16*			
Puzzle-box task									
Persistence (8)	.16*	.34***	.13	-.30***	-.28***	-.09	.13		
Cheating (9)	-.06	-.27***	-.06	.26***	.28***	.11	-.17*	-.94 ***	
Off-task (10)	-.31***	-.28***	-.24**	.19*	.09	-.02	.06	-.47***	.15

Note. $N = 157$ * $p < .05$, ** $p < .01$, *** $p < .001$

Table 3.

Hierarchical regression analyses for persistence, cheating and off-task

			95 % Confidence interval		
Variable	Final model, F (df)	Final β	Upper	Lower	$R^2\Delta$
Persistence	$F(4, 156) = 9.15$***				Model $R^{2=}$ .19
Age		.01	-.15	.16	.02
Temperament					.07
Surgency		-.22**	-.36	-.07	
EF					.10
Inhibition		.24**	.08	.40	
Cog. flexibility		-.17*	-.34	-.01	
Cheating	$F(4, 156) = 6.14$***				Model $R^{2=}$ .17
Age		.07	-.09	.24	.01
Temperament					.09
Surgency		.21**	.06	.36	
Effortful control		-.09	-.24	.06	
EF					.07
Inhibition		-.19**	-.36	-.02	
Cog. flexibility		.18*	.01	.34	
Off-task	$F(4, 152) = 6.08$***				Model $R^{2=}$ .14
Age		-.21*	-.04	-.05	.10
EF					.04
Inhibition		-.16	-.33	.01	.09
Cog. flexibility		.03	-.14	.20	
WM		-.08	-.25	.09	

Note: $N = 157$, * $p < .05$, ** $p < .01$, *** $p < .001$

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