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A Four-Factor Model of Executive Functions in Indonesian Children: Development and Validation of a Parent-Reported Scale

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ABSTRACT

Background: Executive functions (EF) are higher-order cognitive processes essential for learning, self-regulation, and social adaptation in childhood. Despite extensive research in Western contexts, validated EF instruments remain limited in Indonesia. This study aimed to develop and validate a parent-rated EF scale for Indonesian children, based on Diamond's (2013) four-domain model comprising interference control, response inhibition, working memory, and cognitive flexibility.

Method: Skala Fungsi Eksekutif Anak (SK-FEA) was developed by Rexsy Taruna and administered to parents of 549 typically developing children aged 4–12 years. The instrument included 24 items across four subscales, each rated on a 5-point Likert scale. Descriptive statistics were calculated, concurrent validity was examined through intercorrelations among subscales, and construct validity was tested using confirmatory factor analysis (CFA) with a WLSMV estimator.

Result: Descriptive analyses indicated adequate score variability across subscales. All subscales were positively and significantly correlated ($r = 0.51–0.71$, $p < 0.001$), supporting the concurrent validity of the measure. CFA confirmed the hypothesized four-factor structure with excellent fit indices, $\chi^2(246) = 276.12$, $p = .091$, CFI = .999, TLI = .998, RMSEA = .015 (90% CI [.000, .024]), SRMR = .048. All items loaded significantly on their intended factors ($\lambda = 0.31–0.80$, $p < 0.001$).

Conclusion: Findings provide strong evidence for the construct validity of the EFRS as a parent-rated measure of EF in Indonesian children. The instrument captures both the distinctiveness and interrelatedness of EF domains, offering a culturally relevant tool for research and practice. Further studies should examine external validity, predictive validity, and measurement invariance across diverse populations.

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INTRODUCTION

Executive functions (EF) are a set of higher-order cognitive processes that regulate behavior, emotion, and cognition in the service of goal-directed activity. These processes are essential for learning, problem-solving, and adaptive functioning in everyday life (Diamond, 2013). In childhood, EF is critical for school readiness, academic achievement, and social-emotional competence (Baggetta & Alexander, 2016; Best & Miller, 2010). The construct of EF has been extensively studied within the unity and diversity framework, which posits that EF consists of multiple interrelated but separable domains (Friedman & Miyake, 2017; Miyake & Friedman, 2012). According to this perspective, EF tasks share a common underlying mechanism while also reflecting distinct cognitive processes, emphasizing the need for multidimensional assessment tools.

Among the core EF domains, interference control, response inhibition, working memory, and cognitive flexibility are widely recognized as fundamental. Interference control refers to resisting distraction from competing stimuli, while response inhibition involves suppressing prepotent responses. Working memory enables temporary storage and manipulation of information, and cognitive flexibility allows shifting between perspectives, rules, or tasks (Diamond, 2013). Accurate assessment of EF during childhood is important given its associations with literacy, numeracy, and broader academic outcomes (Ribner et al., 2017). Furthermore, deficits in EF are implicated in developmental disorders such as ADHD, specific language impairment, and autism spectrum disorder (Zelazo & Carlson, 2012). These findings highlight the relevance of valid EF measures for both research and clinical contexts.

Most standardized EF instruments have been developed in Western, English-speaking contexts. As a result, their direct application in other cultural settings, such as Indonesia, is limited without adaptation or validation. This creates a gap in available tools for measuring EF in Indonesian children (Zelazo & Carlson, 2012). Developing locally validated instruments is crucial for ensuring cultural and linguistic relevance. Parent-rating scales represent a practical and ecologically valid approach to EF assessment. Parents can observe children across diverse real-life contexts, capturing behaviors that may not be evident in laboratory-based tasks (Toplak et al., 2013). Moreover, rating scales are cost-efficient and feasible for large-scale implementation.

In response to this gap, the present study introduces a new parent-rating EF instrument for Indonesian children, developed by Rexsy Taruna. The instrument includes four subscales: interference control (4 items), response inhibition (9 items), working memory (5 items), and cognitive flexibility (6 items). Each item is rated on a 5-point Likert scale, reflecting the frequency of the behavior. The development of this instrument was guided by Diamond’s (2013) model of EF, which emphasizes the distinct yet interconnected nature of executive processes. This theoretical grounding ensures that the instrument reflects both domain-specific and integrative aspects of EF.

The psychometric evaluation of the instrument focused on three main analyses. First, concurrent validity was assessed through intercorrelations among subscales, which were expected to be significant and positive, consistent with the unity and diversity framework. Second, construct validity was evaluated using confirmatory factor analysis (CFA) with a weighted least squares mean and variance adjusted (WLSMV) estimator, testing the hypothesized four-factor structure (Brown, 2015; Kline, 2016). Third, reliability was examined using McDonald’s ω, a coefficient that provides a robust estimate of internal consistency for congeneric scales (Dunn et al., 2014; McDonald, 1999).

By combining theoretical rigor with statistical validation—including evidence of concurrent validity, construct validity, and reliability- this study contributes to the literature by providing one of the first EF rating instruments developed and tested in Indonesia. The findings are expected to offer a culturally relevant tool for research and practice, while also enriching the global evidence base on the multidimensional structure of EF.

METHOD

Participants

The study involved 549 typically developing children aged 4 to 12 years (M = 8.01, SD = 2.36). The sample comprised 260 boys (47.36%) and 289 girls (52.64%). Children were recruited through schools in Indonesia. Parents reported that their children had no history of neurological or psychiatric diagnoses.

Instrument

Skala Fungsi Eksekutif Anak (SK-FEA) was developed by Rexsy Taruna, based on Diamond's (2013) theoretical framework of EF. The instrument consists of four subscales: interference control (4 items), response inhibition (9 items), working memory (5 items), and cognitive flexibility (6 items). All items are rated by parents using a 5-point Likert scale (1 = never, 5 = always). Higher scores reflect greater EF difficulties as perceived by parents.

Procedure

Parents were asked to complete the SK-FEA individually. Data collection took place either in school settings or at home, depending on the parents' convenience. Standardized instructions were provided by trained research assistants. Participation was voluntary, and informed consent was obtained from all parents prior to data collection.

Data Analysis

Data were analyzed using JASP. Descriptive statistics (means, standard deviations, minimum–maximum) were computed for each subscale. Reliability was assessed using McDonald's ω with 95% confidence intervals, which provides a robust estimate of internal consistency for congeneric scales. Concurrent validity was examined through intercorrelations among the four subscales, consistent with theoretical expectations of positive associations across the EF domains. Construct validity was evaluated using confirmatory factor analysis (CFA) with a weighted least squares mean and variance adjusted (WLSMV) estimator, testing the hypothesized four-factor model. Model fit was assessed using χ^2, CFI, TLI, RMSEA, and SRMR, with cut-off criteria for adequacy following Hu and Bentler (1999).

RESULTS AND DISCUSSION

Descriptive Statistics

As shown in Table 1, participants' ages ranged from 4 to 12 years, with a mean age of 8.01 years (SD = 2.36). The distribution was relatively balanced across age groups, although the largest proportion of children was 8 years old (15.30%), followed by those aged 7 years (14.03%). The smallest proportion was observed at age 12 (7.47%). Table 2 presents the gender distribution of the sample, which was nearly balanced, with 260 boys (47.36%) and 289 girls (52.64%).

Table 1. Age Distribution of Participants (N = 549)

Age (years)	n	%	Cumulative %
4	50	9.11	9.11
5	46	8.38	17.49
6	59	10.75	28.24
7	77	14.03	42.27
8	84	15.30	57.57
9	68	12.39	69.96
10	65	11.84	81.80
11	59	10.75	92.55
12	41	7.47	100.00

Note. Age ranged from 4 to 12 years (M = 8.01, SD = 2.36).

Table 2. Gender Distribution of Participants (N = 549)

Gender	n	%
Boys	260	47.36
Girls	289	52.64

Descriptive statistics for the four executive function subtests are displayed in Table 3. On average, children scored 8.79 (SD = 2.72) on Interference Control, 18.36 (SD = 5.71) on Response Inhibition, 11.05 (SD = 3.66) on Working Memory, and 12.71 (SD = 3.92) on Cognitive Flexibility. Minimum and maximum values indicated adequate variability across all subtests, suggesting that the measures were sensitive to individual differences in executive function performance.

Table 3. Descriptive Statistics for Executive Function Subtests (N = 549)

Subtest	M	SD	Min	Max
Interference Control (IC)	8.79	2.72	4	16
Response Inhibition (RI)	18.36	5.71	9	38
Working Memory (WM)	11.05	3.66	5	25
Cognitive Flexibility (CF)	12.71	3.92	6	26

Note. IC = Interference Control; RI = Response Inhibition; WM = Working Memory: CF = Cognitive Flexibility.

Internal Consistency

The reliability analyses demonstrated that the SK-FEA performs consistently across its subscales. The Interference Control subscale showed excellent internal consistency, as indicated by a McDonald’s ω of .90 (95% CI [.89, .92]), demonstrating that the four items functioned cohesively in measuring the targeted construct. The Response Inhibition subscale exhibited high internal consistency, reflected by a McDonald’s ω of .89 (95% CI [.88, .91]). The nine items included in this subscale showed strong coherence in measuring response inhibition. Additionally, the narrow confidence interval suggests stable and precise reliability estimates, supporting the use of this subscale in both research and applied or clinical contexts.

Similarly, the Working Memory subscale demonstrated high internal consistency, with a McDonald’s ω of .89 (95% CI [.87, .90]). These results indicate that the five items reliably captured individual differences in working memory functioning, with consistency levels suggesting robust measurement precision across respondents.

Finally, the Cognitive Flexibility subscale also showed high internal consistency, as evidenced by a McDonald’s ω of .89 (95% CI [.87, .90]). The six items forming this subscale consistently assessed cognitive flexibility, indicating strong reliability and supporting its suitability for use in empirical research and practical assessment settings.

Table 4. Internal Consistency of Executive Function Subscales (N = 549)

Subscale	Items	McDonald’s ω	95% CI
Interference Control (IC)	4	.90	[.89, .92]
Response Inhibition (RI)	9	.89	[.88, .91]
Working Memory (WM)	5	.89	[.87, .90]
Cognitive Flexibility (CF)	6	.89	[.87, .90]

Theory-Consistent Intercorrelation

Correlation analyses of subtest total scores revealed that all executive function domains were positively and significantly interrelated, with correlation coefficients ranging from .51 to .71 ($p < .001$). The strongest association was observed between working memory and cognitive flexibility ($r = 0.71$, $p < 0.001$), whereas the weakest, though still statistically significant, correlation was found between response inhibition and working memory ($r = 0.51$, $p < 0.001$). In addition, all subtests demonstrated strong correlations with the overall executive function composite score (r = .82 - .85, p < .001), providing robust evidence for the concurrent validity of the instrument.

The strong relationship between working memory and cognitive flexibility is consistent with prior research, which emphasizes the close functional coupling between working memory capacity and mental set shifting (Baggetta & Alexander, 2016; Best & Miller, 2010). Adequate working memory capacity enables individuals to maintain and manipulate task-relevant information, thereby supporting flexible shifts in strategies or perspectives, processes that are critical for learning, problem solving, and adaptive decision making. This pattern aligns with the latent variable models proposed by Miyake et al (2000), which identify working memory updating and shifting as conceptually distinct yet moderately to strongly correlated components of executive functioning.

Furthermore, interference control demonstrated a particularly strong association with response inhibition, supporting neurocognitive models that conceptualize both domains as core elements of attentional control (Diamond, 2013). Within this framework, effective self-regulation requires the ability to suppress prepotent or inappropriate responses while simultaneously filtering out irrelevant or distracting stimuli. This interpretation is further reinforced by the unity-diversity model of executive functions proposed by Friedman and Miyake (2017), which highlights the role of a common executive control factor underlying shared variance among executive domains, particularly those involving attentional regulation.

Finally, the observed pattern of correlations is consistent with Engle's (2002) attentional control model, which conceptualizes working memory capacity as a mechanism for maintaining goal-relevant representations in the presence of interference. From this perspective, strong associations between working memory and other executive domains, particularly cognitive flexibility and inhibitory control, reflect shared reliance on attentional regulation processes that support cognitive self-regulation. Taken together, convergence across empirical findings and multiple theoretical frameworks strengthens the interpretation that the executive function domains assessed by the present instrument are distinct yet interrelated. This pattern reflects a hierarchically organized and integrated executive function system, consistent with contemporary developmental neurocognitive models, and provides further support for the construct validity of the scale.

Confirmatory Factor Analysis

Confirmatory factor analysis provided strong support for the hypothesized four-factor structure of executive functions, yielding an excellent model fit, $\chi^2(246) = 276.12$, p = .091. Additional fit indices further confirmed the robustness of the model (CFI = .999, TLI = .998, RMSEA = .015 [90% CI .000–.024], SRMR = .048), indicating that the proposed factor structure closely matched the empirical data. These results exceed conventional cutoffs for good model fit and suggest a highly stable and well-specified measurement model (Hu & Bentler, 1999; Kline, 2016).

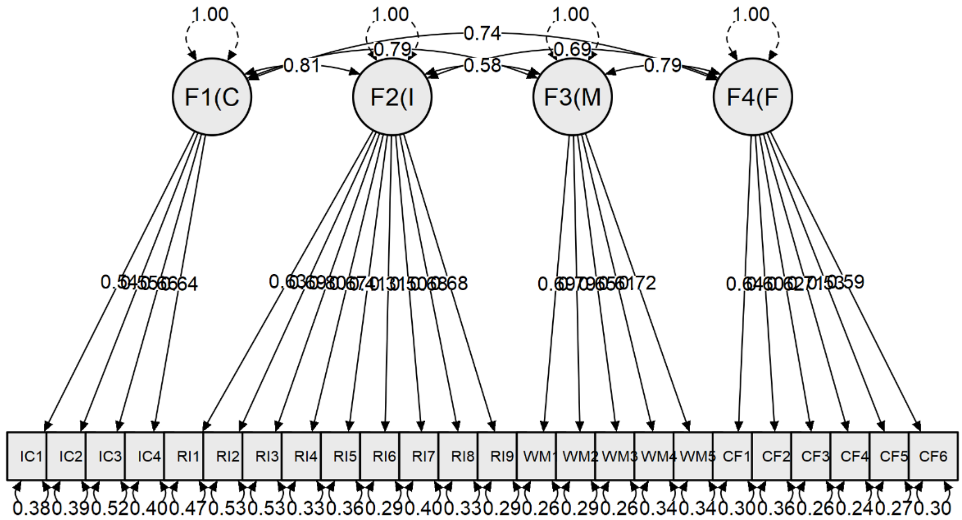

Figure 1. Model plot

All observed indicators loaded significantly on their respective latent factors, with standardized loadings ranging from 0.31 to 0.80 ($p < 0.001$). The majority of factor loadings exceeded .50, indicating that most items were strong representations of their underlying constructs. Although a small number of items exhibited more modest loadings, they remained statistically significant and contributed meaningful variance, a pattern commonly observed in psychological measurement where indicators differ in sensitivity to individual differences (Brown, 2015; Hair et al., 2019). The overall pattern of loadings supports the internal coherence of each subscale while preserving conceptual breadth within domains.

Correlations among the latent factors ranged from 0.58 to 0.81 ($p < .001$), reflecting substantial interrelationships among the executive function domains. This pattern is consistent with the unity and diversity framework of executive functions, which posits that executive domains are distinguishable yet share a common underlying control mechanism (Miyake et al., 2000; Miyake & Friedman, 2012). In this framework, a common executive factor accounts for shared variance across domains, while domain-specific factors capture unique aspects of interference control, response inhibition, working memory, and cognitive flexibility.

Table 5. Model Fit Indices for the Four-Factor CFA Model

Fit Index	**Value**	**Cut-off Criteria***
$\chi^2(246)$	276.12, p = .091	Non-significant preferred
CFI	0.999	≥ .95 = good fit
TLI	0.998	≥ .95 = good fit
RMSEA [90% CI]	0.015 [0.000–0.024]	≤ .06 = good fit
SRMR	0.048	≤ .08 = good fit

Note. Cut-off criteria were based on Hu and Bentler (1999).

Table 6. Standardized Factor Loadings for the Four-Factor Model (N = 549)

Factor	**Item**	**Loading**
Interference Control	IC1	.54
	IC2	.55
	IC3	.66
	IC4	.64
Response Inhibition	RI1	.63
	RI2	.69
	RI3	.80
	RI4	.67
	RI5	.41
	RI6	.31
	RI7	.50
	RI8	.68
	RI9	.68
Working Memory	WM1	.69
	WM2	.79
	WM3	.65
	WM4	.61
	WM5	.72
Cognitive Flexibility	CF1	.64
	CF2	.60
	CF3	.64
	CF4	.71
	CF5	.62
	CF6	.59

Note. All factor loadings were statistically significant at $p < .001$

Table 7. Factor Correlations for the Four-Factor CFA Model

Factor	**IC**	**RI**	**WM**	**CF**
Interference Control (IC)	—	.81	.79	.74
Response Inhibition (RI)		—	.58	.69
Working Memory (WM)			—	.79
Cognitive Flexibility (CF)				—

Note: $p < .001$.

The strong interrelations among factors are further supported by contemporary neurocognitive models, which emphasize the role of domain-general control processes in executive functioning. Friedman and Miyake (2017) argue that executive performance is largely driven by a common control factor associated with goal maintenance and attentional regulation, particularly evident in tasks involving inhibitory control and working memory. Similarly, Diamond (2013) conceptualizes executive functions as an integrated system in which core processes mutually support one another during complex cognitive and behavioral regulation. The present findings align closely with these models, indicating that the four executive domains function as interdependent components within a coordinated cognitive system.

The stability of residual variances and absence of substantial model misfit further suggest that the four-factor solution is efficient and not unduly influenced by measurement error. This supports the psychometric soundness of the instrument and aligns with best-practice recommendations in test development, which emphasize the importance of balancing model parsimony, factor strength, and item reliability (Hair et al., 2019; Kline, 2016). Collectively, these results provide strong evidence for the construct validity of the instrument.

From a methodological standpoint, the use of the WLSMV estimator with polychoric correlations was particularly appropriate given the ordinal nature of the Likert-type response data. Prior simulation studies have demonstrated that WLSMV yields more accurate parameter estimates and fit indices than maximum likelihood estimation when analyzing categorical indicators, especially in developmental and clinical research contexts (Flora & Curran, 2004; Li, 2016; Rhemtulla et al., 2012). The analytical approach adopted in this study, therefore, strengthens the credibility and generalizability of the findings.

Practically, the confirmed construct validity and strong factorial structure suggest that this instrument has considerable utility for both clinical and educational applications in Indonesia. In clinical settings, the scale can facilitate the systematic profiling of executive function strengths and weaknesses, supporting the formulation of diagnoses, intervention planning, and progress monitoring. In educational contexts, the instrument may inform individualized learning supports and classroom accommodations by providing reliable information about children's regulatory and cognitive control capacities.

Finally, the convergence of the present findings with international theoretical and empirical literature reinforces the notion that executive functions represent a universal cognitive construct, while also allowing for culturally specific expressions and measurement considerations. The development and validation of a culturally grounded executive function instrument in Indonesia, therefore, contributes not only to local assessment practices but also to the broader global literature on executive function measurement. As such, this study represents a significant step toward advancing and standardizing valid, reliable, and culturally appropriate executive function assessments.

CONCLUSION

This study provides empirical evidence that the four-factor executive function instrument demonstrates both adequate construct validity and high reliability. The CFA results indicated excellent model fit, with CFI (.999), TLI (.998), RMSEA (.015), and SRMR (.048), all of which meet international standards for model adequacy. The significant intercorrelations among subscales confirmed concurrent validity, while reliability analyses showed that each subscale demonstrated acceptable to high internal consistency (ω = .89 - .90). These findings confirm that interference control, response inhibition, working memory, and cognitive flexibility can be regarded as distinct constructs that are nonetheless closely interrelated, consistent with the unity and diversity framework of EF.

LIMITATIONS

Several limitations should be acknowledged. First, the sample was limited to specific age groups (4–12 years) and did not include sufficient variation in socioeconomic status or regional backgrounds, which may restrict generalizability. Second, the external validity of the instrument has not yet been tested against established criterion measures, such as standardized neuropsychological tasks or teacher and parent report questionnaires. Third, although internal consistency was demonstrated, other aspects of reliability, such as test–retest stability, were not examined.

Future studies should replicate these findings in more diverse samples to improve representativeness and cultural generalizability. Further validation is needed by comparing the instrument with external measures of EF to establish concurrent and criterion validity. It is also important to test measurement invariance across gender, age, and cultural subgroups to ensure the fairness of interpretation. In addition, longitudinal studies should investigate the predictive validity of the instrument in relation to academic achievement, behavioral regulation, and social competence. Finally, integrating the instrument into digital platforms or computer-based assessments could enhance accessibility and efficiency, while expanding its application in both school and clinical settings

REFERENCES

Baggetta, P., & Alexander, P. A. (2016). Conceptualization and operationalization of executive function. *Mind, Brain, and Education*, *10*(1), 10–33. https://doi.org/10.1111/mbe.12100

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, *81*(6), 1641–1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Brown, T. A. (2015). *Confirmatory factor analysis for applied research*. Guilford Press.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dunn, T. J., Baguley, T., & Brunsden, V. (2014). From alpha to omega: A practical solution to the pervasive problem of internal consistency estimation. *British Journal of Psychology*, *105*(3), 399–412. https://doi.org/10.1111/bjop.12046

Engle, R. W. (2002). Working memory capacity as executive attention. *Current Directions in Psychological Science*, *11*(1), 19–23. https://doi.org/10.1111/1467-8721.00160

Flora, D. B., & Curran, P. J. (2004). An empirical evaluation of alternative methods of estimation for confirmatory factor analysis with ordinal data. *Psychological Methods*, *9*(4), 466–491. https://doi.org/10.1037/1082-989X.9.4.466

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex, 86*, 186–204. https://doi.org/10.1016/j.cortex.2016.04.023

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis*. Cengage.

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

Kline, R. B. (2016). *Principles and practice of structural equation modeling*. Guilford Press.

Li, C. H. (2016). Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behavior Research Methods*, *48*, 936–949. https://doi.org/10.3758/s13428-015-0619-7

McDonald, R. P. (1999). *Test theory: A unified treatment*. Lawrence Erlbaum Associates.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex “frontal lobe” tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Rhemtulla, M., Brosseau-Liard, P. É., & Savalei, V. (2012). When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions. *Psychological Methods*, *17*(3), 354–373. https://doi.org/10.1037/a0029315

Ribner, A. D., Willoughby, M. T., & Blair, C. B. (2017). Executive function buffers the association between early math and later academic skills. *Early Childhood Research Quarterly*, *39*, 43–54. https://doi.org/10.1016/j.ecresq.2016.11.001

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry*, *54*(2), 131–143. https://doi.org/10.1111/jcpp.12001

Zelazo, P. D., & Carlson, S. M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives*, *6*(4), 354–360. https://doi.org/10.1111/j.1750-8606.2012.00246.x