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Adaptation and Validation of the Deliberate Practice in Music Inventory for Child Musicians

Adaptierung und Validierung des Deliberate Practice in Music Inventory für Kinder

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Abstract

Deliberate Practice (DP) is a fundamental aspect of musical expertise. Measuring DP in child musicians could provide useful information about its role in determining progress towards higher levels of expertise. This study aims to develop and validate a standardized instrument for measuring the level of DP that child musicians exhibit in their practice routine. The questionnaire is intended to be used by music teachers, parents and child musicians. The Deliberate Practice in Music Inventory (DPMI, Passarotto et al., 2022) for adult musicians was revised and simplified for the use with children by experienced musicians and music educators. The resulting child DPMI (cDPMI) consisted of 11 items, grouped into a main scale and four subscales. Analyses of data collected from a sample of primary school children, their parents, and teachers confirmed the appropriateness of the factor structure of the new questionnaire with good fit indices. The cDPMI main scale and subscales showed acceptable internal consistency in the parents and teachers groups, but internal consistency indices fell below the acceptable level in the children group. The cDPMI was invariant across groups of users (i.e., children, parents, and teachers) and times of measurement. Finally, the cDPMI main scale and subscales were significantly correlated with related personality traits and self-regulatory behaviors, suggesting its convergent validity. In conclusion, the new cDPMI is a standardized and valid instrument for measuring DP in child musicians, although it appears to be particularly suitable as an external evaluation tool for parents and teachers and less suitable as a self-assessment tool for primary school children.

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Keywords

deliberate practice, practice quality, child musicians, questionnaire, expertise

Zusammenfassung

Deliberate Practice (DP) ist ein bedeutender Aspekt im Kontext musikalischer Expertise. Die Erfassung desselben im Kindesalter könnte nützliche Erkenntnisse hinsichtlich der Rolle von DP zur Vorhersage des Verlaufs spieltechnisch-musikalischer Lernprozesse und des Expertiseerwerbs liefern. Ziel dieser Studie war es, ein standardisiertes Instrument zu entwickeln und zu validieren, welches dazu geeignet ist, das DP-Verhalten von Kindern in deren Überoutine zu messen. Der für den Gebrauch von Instrumentallehrkräften, Eltern und Kindern vorgesehene Fragebogen basiert auf dem Deliberate Practice in Music Inventory (DPMI, Passarotto et al., 2022) für erwachsene Musikerinnen und Musiker, welches für den Einsatz bei Kindern überarbeitet und vereinfacht wurde. Das daraus resultierende child DPMI (cDPMI) besteht aus 11 Items, die einer Hauptskala und vier Subskalen zugeordnet sind. Die vorliegende Stichprobe umfasst Daten von Grundschulkindern, deren Eltern sowie deren Instrumentallehrkräften. Die Ergebnisse der Studie bestätigten die postulierte Faktorstruktur des neuen Fragebogens mit guten Anpassungsindizes. Dabei wiesen die cDPMI-Hauptskala und die Subskalen in der Eltern- und in der Lehrkräftegruppe eine akzeptable interne Konsistenz auf, wohingegen sich die Werte für die internen Konsistenzen bei den Kindern als nicht akzeptabel erwiesen. Das cDPMI zeigte sich über die unterschiedlichen Nutzer:innengruppen (d. h. Kinder, Eltern und Lehrkräfte) und die Messzeitpunkte hinweg messinvariant. Statistisch signifikante Korrelationen der cDPMI-Hauptskala und der Subskalen ergaben sich mit Persönlichkeitsmerkmalen und selbstregulatorischem Verhalten, was die konvergente Validität des Fragebogeninventars bekräftigt. Insgesamt liegt mit dem vorliegenden cDPMI ein standardisiertes und valides Instrument zur Messung von DP bei Kindern vor, wobei sich dieses insbesondere als Fremdevaluationstool für Eltern und Lehrkräfte und weniger als Selbsteinschätzungstool für Grundschulkinder zu eignen scheint.

Schlüsselwörter

Deliberate Practice, Übequalität, Grundschulkinder, Fragebogen, musikalischer Expertiseerwerb

Large amounts of practice are necessary for becoming an expert musician. A common rule of thumb suggests that about 10,000 hours or 10 years of practice are required to reach the highest level of expertise in most areas.

In this regard, Ericsson et al. (1993) suggested that specific subtypes of practice could yield more substantial progress than others. They introduced the term *deliberate practice* (DP) to describe a highly structured form of training aimed at refining domain-relevant subskills. DP conceptual core lies in the targeted development of specific components of performance that are objectively identifiable and modifiable through structured training. Practice tasks are typically designed to challenge the learner beyond their current performance level, requiring effort and focused engagement with tasks that disrupt automatized strategies and provoke adaptive changes. This definition highlights four

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fundamental aspects of DP (Ericsson & Harwell, 2019). First, it requires musicians to set clear, specific goals. These goals should be challenging yet attainable and focused on improving specific aspects of performance. Second, DP requires considerable focus and concentration on the task at hand. This can result in significant mental effort. Third, DP must be supported by active monitoring and feedback to help correct errors and refine techniques. Feedback can come from a teacher, a mentor, or through self-assessment. Feedback is a multifaceted factor in DP because, according to Ericsson, both solitary and self-monitored practice as well as proper instruction from expert teachers are essential. On the one hand, access to expert coaching or mentoring can significantly increase the effectiveness of deliberate practice by providing tailored advice, advanced techniques, and structured learning paths, especially in the early stages of learning a musical instrument. On the other hand, solitary practice accounts for most of the practice done during one's career. Therefore, self-regulation, metacognitive skills, and active self-monitoring are necessary to progress to higher levels of musical expertise. Finally, intrinsic motivation provides the perseverance and dedication necessary to overcome the difficulties and fatigue that DP can bring.

In the last decades, several studies have evidenced the importance of DP in performance domains, including medicine (Ericsson, 2004), sports (Macnamara et al., 2016), and music (Platz et al., 2014). A meta-analysis by Platz et al. (2014) revealed a substantial association between measures of DP and musical performance outcomes, with an average effect size of r = .61 (95% CI [.54, .67]). Therefore, DP alone is not sufficient to explain interindividual differences in performance and other factors, such as personality traits and self-regulation, play a crucial role in the development of expertise as well.

Personality traits have been linked to the success of young students. Students who are more open to new experience, conscientious, and agreeable are more likely to achieve higher grades and to show greater commitment than their peers (Alves Ballón Tedesqui, 2019; Duff et al., 2004; O'Connor & Paunonen, 2007). Personality traits are enduring characteristics that influence how individuals think, feel, and behave. They are often categorized using the Big Five model (Chmielewski & Morgan, 2013), which includes openness, conscientiousness, extraversion, agreeableness, and neuroticism. These traits shape a person's motivations, preferences, and interactions, playing an important role in personal and professional success. Previous studies have investigated the interplay between personality traits and deliberate practice (Alves Ballón Tedesqui, 2019; Moxley et al., 2019; Passarotto et al., 2022; Tedesqui & Young, 2020). Traits such as conscientiousness and openness can significantly influence one's ability to engage in deliberate practice. Conscientious individuals, characterized by their diligence, discipline, and organization, are more likely to adhere to the rigorous demands of deliberate practice. Similarly, those high in openness are often more willing to explore novel approaches and persist through challenges.

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Similarly, several studies have shown that self-regulation is a key aspect of academic performance, as it promotes greater compliance with teachers' instructions (Bonneville-Roussy & Bouffard, 2015; Cleary & Zimmerman, 2001). Self-regulation refers to the ability to control one's thoughts, emotions, and behaviors to achieve long-term goals. It encompasses setting goals, monitoring progress, managing emotions, and adjusting strategies to overcome obstacles. This capacity is important for maintaining motivation, focus, and perseverance, especially in the face of challenges and setbacks. Its development is promoted by teacher-student interactions, which lead to progressive acquisition of metacognitive skills and strategies (de Ruig et al., 2023). Self-regulation is strongly related to deliberate practice and its definition (Reverberi et al., 2021; Young et al., 2021, 2023). Effective self-regulation enables individuals to consistently engage in deliberate practice by helping them set realistic goals, maintain focus, and persist despite difficulties. For instance, athletes, musicians, and professionals who excel in their fields often exhibit strong self-regulatory skills, allowing them to manage their practice schedules, cope with pressure, and stay motivated over extended periods. Moreover, self-regulation aids in the strategic planning and reflection necessary for deliberate practice. By regularly assessing their performance and making informed adjustments, individuals can refine their techniques and achieve higher levels of mastery.

Several studies and meta-analyses have raised substantial concerns regarding Ericsson's DP theory (Hambrick et al., 2014, 2020; Macnamara et al., 2014), particularly in the context of musical expertise. Critics argue that the theory suffers from conceptual vagueness, especially in its distinctions between deliberate and other types of practice. Moreover, the role of effort in musical practice is contentious, as different musical instruments demand varying levels of physical and cognitive exertion. Psychophysical effort may not actually improve learning but rather increase the risk of playing-related injuries. Another major limitation lies in the inconsistent methods used to assess DP. Retrospective self-reports tend to yield inflated effect sizes compared to more objective tracking methods, and there is currently no standardized instrument capable of reliably distinguishing deliberate practice from less effective activities. Musicians may misjudge the effectiveness of their routines, favouring traditional practices over empirically validated methods.

To counter these limitations, Passarotto et al. (2022) developed the Deliberate Practice in Music Inventory (DPMI), a self-report questionnaire specifically meant to measure DP in the domain of music. The questionnaire is based on the DP literature and the experience of ten eminent musicians and music educators, gathered through structured interviews. The interviewees were music educators from renowned music universities, such as the Royal College of London, the Hochschule für Musik und Theater München, as well as principals in world famous orchestras, such as the Orchestra del Teatro alla Scala, and the London Symphony Orchestra. The DPMI consists of 23 items outlining a main latent factor, which represents the DP construct in general, and four subfactors,

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which correspond to four facets of DP. The first subfactor is *process improvement* (PI) and it measures the ability of monitoring and improving the effectiveness of strategies implemented during practice sessions. This ability goes beyond the passive execution of practice routines but rather involves proactive and critical thinking, with the goal of maximizing progress. *Practical competences* (PC) are the knowledge needed to solve problems encountered when practicing music. It emphasizes the experience of musicians and refers to the know-how gained through direct experience in the field. *Mindless practice* (MP) measures the extent to which musicians repeat musical passages without setting clear goals and practice plans. The factor has a negative valance as it describes dysfunctional practice behaviors which are not aimed at improving but may put the musicians at risk for repetitive strain injuries. The fourth and last DPMI subfactor is *task decomposition* (TD), a specific practice strategy which consists in dividing long and complex musical segments into simpler elements. In this way, musicians can master difficult repertoires by taking advantage of chunking mechanisms intrinsic to motor learning. The empirical validation showed that the measurement instrument can be reliably used across different samples of musicians, regardless of their level of expertise as well as the musical instrument and genres they play. In addition, DPMI scores have good predictive validity as shown by Passarotto et al. (2025) who compared DPMI scores to ratings of performance quality of audio recordings as self-assessed by performers.

As music education and instrumental instruction often begin at an early age, measuring DP behavior in child musicians could provide useful information about the role of practice behaviors in determining progress towards higher levels of expertise. For example, it may be interesting to assess DP during sensitive periods, when practice can lead to significant cognitive benefits and neuroplastic changes (Altenmüller & Furuya, 2016; Penhune, 2022). In fact, several neuroimaging studies have demonstrated that beginning musical training at a very early age (i.e., before the age of 7) can provide neurological and behavioral benefits that are not seen in musicians who begin playing music later in life. On an educational level, measuring and giving the opportunity to reflect on one's own DP could help young music students to acquire the basic physical and mental skills needed to improve their instrumental learning. Specifically, DP scores could provide standardized feedback for child musicians to regularly reflect on their own work and gain a clearer insight into their strengths and areas for improvement. In addition, DP measures can provide complementary information about musical training, not only measuring the quantity of training achieved, but also providing a principled insight into its quality.

To our knowledge, no existing psychometric tools specifically assess DP in child musicians. Other instruments have explored various dimensions of musical engagement and ability in young learners, such as general musicality, auditory perception, motivational traits, and musical home environment (Buren et al., 2025; McPherson et al., 2018; Müllensiefen et al., 2014; Politimou et al., 2018). Moreover, several tools have been

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developed to evaluate musical abilities directly, through behavioral tasks that measure rhythm discrimination, pitch sensitivity, or melodic memory in children (Gordon, 1979; Peretz et al., 2013). However, these instruments predominantly focus on perceptual or dispositional facets of musical development rather than intentional skill-building through structured training. While the existing DPMI has proved useful in explaining the effects of musical practice in adult musicians Passarotto et al. (2025), it is not a suitable measurement tool for the use with children due to its lengthy structure and the complexity of the language used.

The present study aims to develop and validate the child DPMI (cDPMI), an adaptation of the DPMI designed to measure DP behavior in child musicians, particularly between the age of 5 and 12 years. The questionnaire is intended for use by music teachers, parents, and child musicians themselves. In terms of validity, we expect to find a significant association between cDPMI, self-regulation and personality traits measures, given their role in the development of musical expertise (Bonneville-Roussy & Bouffard, 2015; Burak & Atabek, 2023; Kuckelkorn et al., 2021; Passarotto et al., 2022).

Method

Participants

195 families, 206 children and 84 teachers took part in the longitudinal study ELEMUG (Bieber, 2025; Bieber et al., 2024), which was conducted at the Hector Research Institute of Education Sciences and Psychology (University of Tübingen), starting data collection in 2021. The study was approved by the Ethics Committee of the Faculty of Economics and Social Sciences at the University of Tübingen (approval number: A2.5.4-189_ns). All participants provided written informed consent to participate in the study. The data presented in this manuscript are part of those collected during the ELEMUG study, which had the broader objective of exploring the relationship between parental beliefs and the development of musical skills during childhood. For the current study, data came from three groups of participants who all had completed the cDPMI: children (N = 140), their parents or legal guardians (N = 128) and their instrumental teachers (N = 80). At the beginning of the study, children had a mean age of 7.6 years (5–12 years) and 40.8% of them were female. They had just started taking instrumental lessons at one of the 25 music schools in Baden-Württemberg (Germany) taking part in the study and played 20 different instruments. Of the subjects in the parents group, 78.1% were female, with an overall mean age of 41.45 years (range: 27–73 years). 71.8% were German, followed by those with Russian (3.9%), French (3.1%), and Romanian (2.3%) citizenship. 28.0% had a university degree, including PhD (5.4%), Master's (18.7%), and Bachelor's degrees (3.9%). The final dataset included 52 complete triads (i.e., child-parent-teacher combination), 82

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dyads and 31 individual entries. 11 families and 42 teachers had more than one child or student participating in the study.

Procedure

The study involved monitoring the progress of 206 child musicians during their first year of instrumental lessons. Child musicians, their parents and their instrumental teachers filled out a battery of questionnaires at the onset of instrumental lessons (T0), about six months later (T1) and after about one year had passed (T2). During the one-year monitoring period, the children received instrumental tuition on a weekly basis in various formats, including one-to-one lessons (55.3%) and group lessons (13.6%).

All participants filled out the cDPMI questionnaire at T1 and T2. Parents additionally completed the self-regulation and Big Five questionnaires at T0 to describe their children's self-regulation and personality traits at the beginning of the study. This is in line with common practice in educational and developmental psychology studies where parent reports are commonly used to gather information about preschool children who, due to their age, may have limited literacy and metacognitive skills (Göllner et al., 2017; Kochanska & Aksan, 2006; Soto & John, 2014). To accommodate potential reading difficulties among child musicians, all items were professionally recorded by an actress so that the children could read or listen to them. Consequently, the child musicians were able to complete the questionnaire independently. No support or guidance was provided when parents were asked to judge practice behaviors. This was to ensure that parents were free from the influence of music educators when filling out the questionnaire. Parents and teachers could select "I cannot judge this" ("Kann ich nicht beurteilen") if unable to judge specific aspects of DP.

Materials

The development of the cDPMI was supported by two expert musicians and music educators who revised the 23 items of the original adult DPMI questionnaire to adapt it for child musicians between the age of 5 and 12 years. Reviewers were asked to a) simplify and reword existing items, retaining as much of their original meaning as possible, b) to eliminate items the content of which was not appropriate for the intended target population of children, or c) to propose new items congruent with the DP construct. The resulting item set was then discussed and refined together with the authors of this study. The final version of the cDPMI consisted of 11 items and retained the same theoretical and psychometric factor structure of the adult DPMI questionnaire (i.e., one main factor and four subfactors). Questionnaire items and scoring instructions are provided in Appendix 1.

For establishing convergent validity via correlations, the study included two additional self-report questionnaires, namely an adaptation of the Self-Regulation of Learning

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Self-Report Scale (Toering et al., 2012) and the Big Five short scale (Lang, 2005). The Self-Regulation of Learning Self-Report Scale consists of 10 items scored on a 1-to-4 Likert scale of agreement and it measures the extent to which individuals have control over their behavior and emotions while learning. The Big Five short scale consists of the following subscales: *extraversion*, *conscientiousness*, *neuroticism*, *agreeableness,* and *openness*. It is composed of 16 items, which are scored on a 1-to-7 Likert scale of agreement. Previous studies have demonstrated that these questionnaires are suitable for use in childhood from parents' perspective, indicating their value as a consistently applicable measure of personality traits across different developmental stages (Barbaranelli et al., 2003; Brandt et al., 2020, 2021; Koivuniemi et al., 2021; Measelle et al., 2005). Demographic information about the children and their parents was also collected. Note that the ELEMUG study included more instruments than those considered here. These are described in detail elsewhere (Bieber, 2025; Bieber et al., 2024)

Analyses

A confirmatory factor analysis (CFA) was run to assess the generalizability of the factor structure of the original DPMI questionnaire, a bifactor structure with one main and four group factors, to the cDPMI. Thus, each of the 11 items composing the new questionnaire was assigned to a main factor as well as to four subfactor, namely *practice competences* (4 items), *process improvement* (3 items), *mindless practice* (3 items), and *task decomposition* (1 item). The cDPMI bifactor structure was set to be orthogonal. As the TD subscale only contained one item, it was forced to load entirely on the TD latent factor, setting its residual variance to 0. Model fit was evaluated considering χ^2, root mean square error of approximation (RMSEA), standardized root mean squared residual (SRMR), Tucker-Lewis index (TLI), and comparative fit index (CFI) values.

The internal consistency (i.e. reliability) of the cDPMI main and subscales was evaluated by considering McDonald's ω and Cronbach's α values. Since these coefficients are sensitive to the number of items in the scale and at least Cronbach's alpha tends to underestimate the reliability of short inventories (i.e., less than 10 items), we followed Pallant's (2020) recommendation and reported the average inter-item correlation values, referred to as r-bar. According to Briggs and Cheek (1986), r-bar values between .2 and .4 should be considered acceptable. Internal consistency was tested separately for each group and measurement time.

Factorial invariance (FI) analyses assessed whether the DPMI factor structure fitted equally well with the data from different groups of users (child musicians, parents, and teachers) and collected at different times (T1 and T2). This analysis tests whether the model fit remains unchanged when structural constraints are progressively applied. FI was tested on nested models, according to the following order: configural invariance (i.e. constraining only factors' structure), metric invariance (i.e. adding constraints to factor loadings), and scalar invariance (i.e. additionally constraining item intercepts). These

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nested models were compared in terms of χ^2 values, to assess significant differences between constraint levels. As a rule, if $p > .05$, constraints do not significantly affect the model fit and factorial invariance is supported. In addition, CFI, RMSEA, and their change across constraint levels were also computed: changes smaller than .010 (or larger than -.010 in case of a negative value) in both indices were considered evidence of invariance (Svetina et al., 2020). FI for user groups and measurements time were tested separately. Moreover, FI across user groups was evaluated cross-sectionally, considering the data collected at T0 only. This was the timepoint with the most complete data.

Correlation matrices were used to investigate the relationship between cDPMI scores and other scales measuring constructs related to DP, namely self-regulation, *extraversion*, *conscientiousness*, *neuroticism*, *agreeableness,* and *openness*. The data considered at this stage came from the questionnaires filled out by the parents at T0.

Since participants were allowed to skip questionnaire items if they wanted to, missing values were generated during the data collection process. The proportion of missing values was below 10% of observations (see Appendix 2). To limit the loss of information, in the CFA and FI models missing values were estimated by full information maximum likelihood methods. This method allows to reliably estimate model parameters even in presence of missing data.

In contrast, internal consistency and correlation coefficients were calculated on complete observations only (i.e., with no missing values), resulting in variable sample sizes depending on the pair of variables considered. This conservative approach was preferred to alternatives based on data imputation, as these techniques can increase the risk of type 1 errors and the identification of spurious correlations between variables.

To ensure the independence of the observations, for each parent and teacher who had more than one child participating in the study, only the case with the fewest missing values was selected for CFA, internal consistency, and FI analyses.

All analyses were run in R-studio (RStudio Team, 2023), with the *lavaan* (Rosseel, 2012), and *psych* (Revelle, 2017) R-packages.

Results

The results of the CFA confirmed the factor structure of the cDPMI with excellent fit indices ($\chi^2 = 61.093$, $df = 35$, $p < .001$ RMSEA = .044, SRMR = .040, TLI = .922, CFI = .950). As shown in Table 1, the cDPMI main factor showed acceptable internal consistency for the parents and teachers groups, with Cronbach's α and McDonald's ω values greater than .753, and r-bar values greater than .216.

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Table 1

Internal Consistency Metrics for the cDPMI Main Scale Across Groups and Measurement Times

Time	Group	*N*	alpha	omega	r-bar
T1	overall	265	0.707	0.713	0.180
T1	parents	84	0.753	0.757	0.217
T1	children	114	0.570	0.592	0.108
T1	teachers	67	0.815	0.819	0.286
T2	overall	252	0.723	0.731	0.192
T2	parents	71	0.772	0.776	0.236
T2	children	108	0.542	0.551	0.097
T2	teachers	73	0.835	0.843	0.314

These indices were lower for the children group, with Cronbach's α and McDonald's ω values ranging from .542 to .592 and r-bar values below .2, suggesting questionable internal consistency. Similar results were found for the four cDPMI subscales (see Appendix 3): for the parents and teachers groups, Cronbach's α, McDonald's ω, and r-hat values were within the acceptable range. The children group achieved acceptable internal consistency for the PI subscale only, r-hat > .202, while internal consistency for the PC, MP subscales was questionable, with r-hat values below .2. Descriptive statistics and deciles for each cDPMI scale are reported in Appendix 4.

Table 2 shows a summary of the FI analyses for user groups and measurement times. As shown in the upper part of the table, the model testing group invariance achieved full configural and metric invariance across the three groups of users. Nevertheless, scalar invariance was only achieved after allowing the intercept of the items "when I practice, I don't play the way my teacher told me to play" and "when I practice, I just play along" to vary. Therefore, the modified model testing group invariance achieved partial scalar invariance across user groups. The lower part of Table 1 shows that the model testing time invariance achieved full configural, metric and scalar invariance across measurement times. All the models computed during the FI analyses had acceptable fit indices, with CFI and TLI values in all cases higher than .869 as well as RMSEA and SRMR values lower than 0.081.

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Table 2

Factorial Invariance Analyses Across Groups and Measurement Times

Invariance level	*df*	AIC	BIC	X^2	CFI	RMSEA	ΔX^2	ΔCFI	ΔRMSEA
User groups[a]									
Configural	108	7549.6	8023.4	134.5	.916	.046			
Metric	142	7524	7866.9	176.9	.916	.046	36.7	> .001	> .001
Scalar[b]	147	7521.8	7845.4	184.8	.912	.047	9.7	-.002	.001
Time									
Configural	72	14636	15004	115.1	.950	.038			
Metric	89	14623	14915	136.6	.945	.040	19.6	-.005	.002
Scalar	95	14616	14882	141.8	.945	.042	5.33	> -.001	.002

[a]FI for user groups was tested cross-sectionally, only analyzing data collected at T1. [b]Scalar invariance was achieved after allowing the intercept of two items to vary across user groups.

The results of the correlation analysis are reported in Table 3. The cDPMI main factor was positively and significantly related to self-regulation as well as three dimensions of the Big Five short scale (Lang, 2005), namely, *extraversion*, *conscientiousness*, and *agreeableness*. The four cDPMI subfactors showed similar correlation trends with the only exception of *mindless practice* (MP), which was negatively correlated to most of the variables included in the analysis, as was expected.

Table 3

Correlation Between cDPMI, Personality Traits and Self-Regulation Scores

Variable	Main cDPMI score	PI	PC	MP	TD
Extraversion	0.215*	0.299**	0.001	-0.203*	0.225*
Conscientiousness	0.457***	0.280**	0.345***	-0.304**	0.094
Neuroticism	0.018	-0.013	-0.034	-0.123	0.016
Agreeableness	0.367***	0.256*	0.190*	-0.305**	0.104
Openness	0.172	0.173	0.089	-0.112	-0.069
Self-regulation	0.412***	0.277**	0.356***	-0.238*	0.192*

Note. Due to missing values, correlation coefficients were computed with different sample sizes, ranging between $N = 82$ and $N = 116$. PI = process improvement; PC = practice competences; MP = mindless practice; TD = task decomposition. Data was collected from parents, i.e. personality and self-regulation data at T0 and cDPMI data at T1.
*$p < .05$. **$p < .01$. ***$p < .001$.

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Discussion

The present study aimed at developing and validating the cDPMI, an adaptation of the DPMI for child musicians, especially between 5 and 10 years of age. The questionnaire was designed to be used by music teachers, parents and child musicians, as an evaluation tool for music practice behavior in children.

The cDPMI is composed of 11 items and retains the bifactor structure of the adult DPMI, consisting of a main scale and four subscales. Confirmatory factor analyses confirmed the appropriateness of the cDPMI factor structure with good fit indices. The cDPMI main scale and subscales showed acceptable internal consistency in the parents and teachers groups, but internal consistency indices fell below the acceptable level in the children group. The cDPMI model proved invariant across different groups of users (i.e., children, parents, and teachers) and time of measurement. Finally, the cDPMI main scale and subscales were significantly correlated with self-regulation, as well as three personality traits, namely, *extraversion*, *conscientiousness*, and *agreeableness.*

The analyses revealed a questionable level of internal consistency for the cDPMI main scale and subscales in the children group, except for the *process improvement* subscale. This may be because *practice competences* and *mindless practice* subscales require a degree of introspection and knowledge that the young participants did not have due to their age (mean age = 7.6 years) and still low level of musical expertise. Therefore, the cDPMI may be less reliable as a self-assessment tool for young musicians than as a tool for the teachers and parents to monitor practice behaviors of their students and children. The validity of the cDPMI was assessed by considering multiple aspects. Content validity was assured by the expertise of the reviewers who adapted the DPMI while structural validity was supported by the good fit indices of the cDPMI factor structure. Convergent validity was demonstrated through significant correlations with DP-related constructs, such as self-regulation and personality traits. FI testing evaluated the generalizability aspect of validity while significant correlations between the cDPMI scales and other measures related to DP support the external validity of the new questionnaire. Criteria for configural and metric FI were satisfied. This suggests that the cDPMI factor structure fits similarly well the data from the three user groups, with similar correlation patterns between items. Scalar invariance was achieved only partially. Thus, cDPMI scores collected from different user groups may not be comparable in absolute terms, as intercept values for two items vary substantially across groups. However, group-level comparisons may be reasonably conducted on the PI, PC, and TD subscales, which are computed without the two problematic items. Analyses on the rank order of observations across groups (i.e., correlation analyses) may also be appropriate.

Self-regulation is well-known to be a significant predictor of young musicians' success and a crucial aspect of musical expertise (Bonneville-Roussy & Bouffard, 2015; McPherson & Renwick, 2001; Miksza, 2015; Varela et al., 2016). *Extraversion* and *conscientiousness* are typically correlated with the rate of music practice in early childhood

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(Burak & Atabek, 2023; Marion-St-Onge et al., 2020). Previous studies have shown that *extraversion* and *agreeableness* might be significantly higher in musicians than in non-musicians and positively correlated with the duration of musical training (Corrigall et al., 2013; Corrigall & Schellenberg, 2015; Kuckelkorn et al., 2021). Thus, *extroversion*, *conscientiousness* and *agreeableness* could indicate a good compliance with the teacher instructions and promote the continuation of music education in the long term. *Neuroticism* and *openness* were not significantly correlated with cDPMI scores. This is surprising, as previous findings suggest that musicians might show higher levels of *neuroticism* and *openness* to new experience than non-musicians (Corrigall et al., 2013; Miranda, 2020; Vaag et al., 2018). However, the findings by Kuckelkorn et al. (2021) indicate that the association between personality traits and DP might not be found in novices but rather characterize expert performers. Thus, *neuroticism* and *openness* may either develop later in life or be a selection criterion for higher levels of expertise: only musicians who exhibit these traits may have the resources necessary to persist in musical studies.

The results of this study demonstrate a strong conceptual and empirical alignment between the cDPMI and Ericsson's definition of deliberate practice. Similarly to the DPMI, the cDPMI implements the DP's core principles through subscales that measure children's practical skills, ability to monitor improvement, avoidance of mindless repetition and ability to break down tasks strategically. Moreover, the cDPMI's convergent validity is substantiated by its significant correlations with self-regulation and personality traits such as conscientiousness and agreeableness—traits previously shown to facilitate engagement in DP (Bonneville-Roussy & Bouffard, 2015; Passarotto et al., 2022). The negative relationship between MP (i.e., mindless practice subscale) and these traits also supports Ericsson's view that passive repetition is insufficient for skill acquisition (Ericsson, 2020). The low reliability of children's self-reports yielded, especially in subscales requiring metacognitive insights (i.e., PC and MP subscales), may reflect the developmental trajectory of self-monitoring skills in young musicians, consistent with Ericsson's emphasis on expert guidance in early stages of practice (Ericsson, 2008).

This study has important implications for the music education research field. The lower consistency in child musicians' responses compared to the other groups may depend on the limited understanding of the key aspects of musical practice in this population. While children seem to recognize their own progress and to use the *process improvement* subscale appropriately, they show uncertainty about their own competencies and a poor understanding of dysfunctional practice behaviors, as evidenced by the improper use of the *practice competences* and *mindless practice* subscales (see Appendix 3). This highlights the importance of teachers and their feedback in acquiring the necessary skills to become expert musicians (de Bruin, 2023; Duke & Simmons, 2006). On the other hand, our results discourage music educators from relying too much on the monitoring skills of their young students. Instead, they should involve parents in monitoring their students' practice behaviors at home and to support the acquisition of

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good practice habits in the early stages of learning a musical instrument. In addition, our results highlight the importance of teaching methods that prioritize the acquisition of functional behaviors and good practice habits over repertoire mastery in children. In fact, while the latter may be the key to prodigy in the short term, the former promotes a scaffolding process that allows for stable improvements in the long term (Biasutti, 2017; Bolhuis, 2003).

This study comes with some limitations. First, cDPMI subscales such as *practice competences* and *task decomposition,* are quite specific to abilities and practice routines that might not be well developed in the children and novices yet. Therefore, these cDPMI subscales may be less applicable as self-report tools, and researchers should be aware of the reliability issues with child self-reports mentioned in the previous paragraphs. Second, due to the limited sample size, we could not evaluate FI across child musicians playing different musical instruments. For the same reason, we were unable to analyze possible age-related differences in how child musicians completed the questionnaires, which may partly explain the poor consistency found in their data. Furthermore, the limited sample size does not allow to produce reliable normative data, which limits the extent to which cDPMI scores can be interpreted in absolute terms. However, we still believe that the cDPMI can already be used with confidence as an educational tool, particularly for monitoring changes in individual behaviors over time. Third, the study was conducted based on the assumption that constructs measured (i.e., deliberate practice, personality traits) are stable and measurable throughout childhood, a premise that may not apply to younger children. Fourth, the different teaching approaches included in the study (i.e., one-to-one and group lessons) may have affected the way child musicians self-evaluated their practice behaviors and potentially contributed to the reliability issues evidenced in the results. Future studies might explore the relationship between the cDPMI scores and the development of psychomotor and auditory abilities in children. In addition, researchers could use the cDPMI to better investigate the role of practice along the path to musical expertise, considering not only the amount of practice but also its quality. Fifth, to receive uninfluenced assessments from parents, no guidelines were provided. Future studies may investigate the effect of guidelines for the targeted observation and assessment of DP in children, as guidelines could prevent undesirable influences from their general behavior and personality traits. Finally, the reduced sample size did not allow us to explore alternative factor solutions that might provide a better fit to our data.

In conclusion, the cDPMI is a valid instrument for measuring DP behavior in child musicians, at least when used with parents and teachers. This compact questionnaire can be used as an external assessment tool as well as a self-assessment tool, although in the latter case the age of the children and the complexity of the constructs underpinning DP may limit the reliability of the measurements. We believe that the cDPMI is a valuable

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contribution to music education and expertise research fields, providing a standardized measure of the quality of practice in the initial stages of music learning.

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Appendix

Appendix 1. Deliberate Practice in Music Inventory for Child Musicians (cDPMI) in German and English, Phrased From the Teacher's, Parent's, and Child's Perspective

Teacher's Perspective

Die folgenden Fragen beziehen sich auf das Übeverhalten des Kindes.

The following questions relate to the child's practice behaviors.

Item	Text	Nie *Never*	Selten *Rarely*	Manchmal *Sometimes*	Immer *Always*
1	Das Kind weiß, was es tut. *The child knows what he/she is doing.*	1	2	3	4
2	Das Kind weiß, was es erreichen will. *The child knows what he/she wants to achieve.*	1	2	3	4
3	Das Kind merkt, wenn es Fehler macht. *The child realizes when he/she makes mistakes.*	1	2	3	4
4	Wenn das Kind Schwierigkeiten hat, fragt es mich. *If the child has difficulties, he/she asks me.*	1	2	3	4
5	Das Kind macht die Übungen, die ich ihm gebe. *The child does the exercises I give him/her.*	1	2	3	4
6	Das Kind weiß nicht, wie es besser üben soll. *The child does not know how to practice better.*	1	2	3	4
7	Das Kind merkt, wenn es besser wird. *The child notices when he/she is getting better.*	1	2	3	4
8	Das Kind spielt nicht so, wie ich es gesagt habe.	1	2	3	4

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	The child doesn't play the way I told him/her to play.				
9	Das Kind spielt einfach so vor sich hin. *The child just plays as it comes.*	1	2	3	4
10	Das Kind wiederholt dieselben Fehler. *The child repeats the same mistakes over and over.*	1	2	3	4
11	Das Kind übt die schwierigen Stellen besonders oft. *The child practices the difficult parts often.*	1	2	3	4

Hinweise für die Auswertung: Die Punkte der einzelnen Items werden für die folgenden Subskalen berechnet. 'R' bedeutet, dass die Items zuerst invertiert werden.
Notes for the researchers: scores are calculated according to the following indications. 'R' indicates items in their reversed form.

DP Main Score = 1, 2, 3, 4, 5, 6R, 7, 8R, 9R, 10R, 11
Process improvement = 3, 4, 7
Practice competences = 1, 2, 5, 6R
Mindless practice = 8, 9, 10
Task decomposition = 11

Parent's Perspective

Die folgenden Fragen beziehen sich auf das Übeverhalten Ihres Kindes daheim.
The following questions relate to your child's practice behaviors at home.

Item	**Text**	**Nie** *Never*	**Selten** *Rarely*	**Manchmal** *Sometimes*	**Immer** *Always*
1	Mein Kind weiß, was es tut. *My child knows what he/she is doing.*	1	2	3	4
2	Mein Kind weiß, was es erreichen will. *My child knows what he/she wants to achieve.*	1	2	3	4
3	Mein Kind merkt, wenn es Fehler macht. *My child realizes when he/she makes mistakes.*	1	2	3	4
4	Wenn mein Kind Schwierigkeiten hat, fragt es seine/n Lehrer/in. *If my child has difficulties, he/she asks his/her teacher.*	1	2	3	4
5	Mein Kind macht die Übungen, die der/die Lehrer/in ihm gibt. *My child does the exercises the teacher gives him/her.*	1	2	3	4
6	Mein Kind weiß nicht, wie es besser üben soll. *My child does not know how to practice better.*	1	2	3	4
7	Mein Kind merkt, wenn es besser wird. *My child notices when he/she is getting better.*	1	2	3	4
8	Mein Kind spielt nicht so, wie der/die Lehrer/in es gesagt hat.	1	2	3	4

	My child doesn't play the way the teacher told him/her to play.				
9	Mein Kind spielt einfach so vor sich hin. *My child just plays as it comes.*	1	2	3	4
10	Mein Kind wiederholt dieselben Fehler. *My child repeats the same mistakes over and over.*	1	2	3	4
11	Mein Kind übt die schwierigen Stellen besonders oft. *My child practices the difficult parts often.*	1	2	3	4

Hinweise für die Auswertung: Die Punkte der einzelnen Items werden für die folgenden Subskalen berechnet. 'R' bedeutet, dass die Items zuerst invertiert werden.
Notes for the researchers: scores are calculated according to the following indications. 'R' indicates items in their reversed form.

DP Main Score = 1, 2, 3, 4, 5, 6R, 7, 8R, 9R, 10R, 11
Process improvement = 3, 4, 7
Practice competences = 1, 2, 5, 6R
Mindless practice = 8, 9, 10
Task decomposition = 11

Child's Perspective

Die folgenden Fragen beziehen sich auf das Üben Deines Instruments daheim.
The following questions relate to the practice of your musical instrument at home.

Item	**Text**	**Nie** *Never*	**Selten** *Rarely*	**Manchmal** *Sometimes*	**Immer** *Always*
1	Beim Üben weiß ich, was ich tue. *When I practice, I know what I am doing.*	1	2	3	4
2	Beim Üben weiß ich, was ich erreichen will. *When I practice, I know what I need to achieve.*	1	2	3	4
3	Ich merke beim Üben, wenn ich Fehler mache. *When I practice, I notice when I make mistakes.*	1	2	3	4
4	Wenn ich beim Üben Schwierigkeiten habe, frage ich meine/n Lehrer/in. *If I have difficulties when practicing, I ask my teacher.*	1	2	3	4
5	Ich mache die Übungen, die mir mein/e Lehrer/in gibt. *I do the exercises that my teacher gives me.*	1	2	3	4
6	Ich weiß nicht, wie ich besser üben soll. *I don't know how to practice better.*	1	2	3	4
7	Ich merke beim Üben, wenn ich besser werde. *I notice when I get better while practicing.*	1	2	3	4
8	Beim Üben spiele ich nicht so, wie es mein/e Lehrer/in gesagt hat.	1	2	3	4

	When I practice, I don't play the way my teacher told me to play.				
9	Beim Üben spiele ich einfach so vor mich hin. *When I practice, I just play along.*	1	2	3	4
10	Beim Üben wiederhole ich dieselben Fehler. *When I practice, I repeat the same mistakes over and over.*	1	2	3	4
11	Ich übe die schwierigen Stellen besonders oft. *I practice the difficult parts particularly often.*	1	2	3	4

Hinweise für die Auswertung: Die Punkte der einzelnen Items werden für die folgenden Subskalen berechnet. 'R' bedeutet, dass die Items zuerst invertiert werden.
Notes for the researchers: scores are calculated according to the following indications. 'R' indicates items in their reversed form.

DP Main Score = 1, 2, 3, 4, 5, 6R, 7, 8R, 9R, 10R, 11
Process improvement = 3, 4, 7
Practice competences = 1, 2, 5, 6R
Mindless practice = 8, 9, 10
Task decomposition = 11

Appendix 2. Proportion of Missing Entry for Each Item of the Cdpmi Questionnaire, Grouped by Time of Measurement and User Group

time	group	DP1	DP2	DP3	DP4	DP5	DP6	DP7	DP8	DP9	DP10	DP11
T1	parents	0.008	0.047	0.000	0.017	0.039	0.086	0.031	0.020	0.023	0.086	0.062
T1	children	0.036	0.014	0.043	0.029	0.036	0.036	0.014	0.007	0.029	0.007	0.007
T1	teachers	0.000	0.012	0.012	0.012	0.012	0.062	0.025	0.012	0.025	0.000	0.049
T2	parents	0.018	0.045	0.009	0.018	0.036	0.109	0.027	0.024	0.009	0.073	0.027
T2	children	0.000	0.008	0.024	0.016	0.016	0.024	0.024	0.000	0.008	0.000	0.008
T2	teachers	0.012	0.036	0.000	0.000	0.000	0.048	0.012	0.000	0.012	0.000	0.048

Appendix 3. Internal Consistency for the cDPMI Subscales Across Groups and Measurement Times

cDPMI Subscale	Time	Group	*N*	alpha	omega	r-bar
PI	T1	overall	307	0.563	0.569	0.301
PI	T1	parents	102	0.531	0.537	0.274
PI	T1	children	129	0.560	0.571	0.298
PI	T1	teachers	76	0.620	0.672	0.352
PI	T2	overall	284	0.489	0.501	0.242
PI	T2	parents	88	0.515	0.528	0.261
PI	T2	children	115	0.433	0.439	0.203
PI	T2	teachers	81	0.564	0.649	0.301

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cDPMI Subscale	Time	Group	*N*	alpha	omega	r-bar
PC	T1	overall	309	0.517	0.537	0.211
PC	T1	parents	110	0.543	0.556	0.229
PC	T1	children	125	0.396	0.446	0.141
PC	T1	teachers	74	0.629	0.643	0.298
PC	T2	overall	287	0.514	0.556	0.209
PC	T2	parents	93	0.591	0.632	0.266
PC	T2	children	117	0.307	0.389	0.100
PC	T2	teachers	77	0.667	0.710	0.334
MP	T1	overall	312	0.456	0.459	0.219
MP	T1	parents	101	0.390	0.392	0.176
MP	T1	children	134	0.293	0.318	0.122
MP	T1	teachers	77	0.749	0.758	0.499
MP	T2	overall	285	0.436	0.454	0.205
MP	T2	parents	82	0.553	0.555	0.292
MP	T2	children	122	0.260	0.413	0.105
MP	T2	teachers	81	0.709	0.719	0.448

Note. PI = process improvement, PC = practice competences, MP = mindless practice. Internal consistency was not tested on the task decomposition subscale as it is a one-item scale.

Appendix 4. Descriptive Statistics and Deciles for the cDPMI Scales Across Groups

Deliberate Practice in Music Inventory for Child Musicians (cDPMI) - normative values

		Parents (*N* = 128)					Children (*N* = 140)					Teachers (*N* = 80)				
		DP_main	PC	PI	MP	TD	DP_main	PC	PI	MP	TD	DP_main	PC	PI	MP	TD
Deciles	10%	30	11	9	5	2	31	12	8	4	2	27.9	10	8	4	2
	20%	33	12	9	5	2	33	13	9	4	3	30	11	9	5	2
	30%	34	13	10	6	3	35	13	10	5	3	33	12	10	6	2
	40%	35	13	10	6	3	36	13	10	5	3	33	13	10	6	3
	50%	35	14	11	7	3	36	14	11	6	3	35	13	11	6	3
	60%	36	14	11	7	3	37	14	11	6	4	36	14	11	7	3
	70%	37	14	11	7	3	38	15	11	7	4	37	14	11	8	3
	80%	38	15	11	8	3	39	15	12	7	4	38	14	12	8	4
	90%	39	15	12	8	4	41	16	12	8	4	40	15	12	9	4
	100 %	43	16	12	12	4	44	16	12	11	4	44	16	12	11	4
Mean		35.0	13.3	10.3	6.6	2.8	36.2	13.7	10.2	5.9	3.3	34.4	12.8	10.3	6.6	2.8
Std. Deviation		3.9	1.5	1.3	1.5	0.8	3.6	1.6	1.6	1.8	0.8	4.9	1.9	1.5	1.8	0.9
Minimum		19	8	5	3	1	25	8	5	3	1	22	7	5	3	1
Maximum		43	16	12	12	4	44	16	12	11	4	44	16	12	11	4

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