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Moving towards Ecological Validity: Conceptions and Measurement of Children's Musicality

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Verena Buren

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"I believe that in an effort to control stimuli and reduce music to its atomic elements, the makers of standardized tests have removed its essence, its dynamic and emotional nature. In short, they have removed the muse from music." (Levitin, 2012, p. 635)

Abstract

Although child musicality is inherently rich and diverse, assessments often reduce it to isolated, predominantly aural abilities. This reductionist approach compromises the ecological validity of the assessments by detaching musicality from its real-world context, thereby limiting a more nuanced understanding. Reframing musicality as a social construct that is shaped by cultural conceptions of music and aesthetics addresses these limitations by acknowledging its contextual and dynamic nature. From this perspective, caregivers, educators, and music professionals can provide essential insights based on their observations of children's musical behavior in natural contexts, ultimately deepening our understanding of musicality.

This dissertation contributes to the improvement of the ecological validity of musicality assessments by integrating the perspectives of parents, educators, and music professionals. Its goal is to advance research on musical development by providing a framework that reflects the complexity of musicality. In Study 1, conceptions of child musicality (ages 3 to 6 years) were examined and compared to those of adult musicality. Study 2 focused on infants and toddlers (under 3 years of age) and explored differences in conceptions within childhood. Study 3 developed a brief screening tool that allows parents and educators to assess individual differences in children's musicality (ages 3 to 10 years). It was grounded in a broad conception of musicality and evaluated for its psychometric properties.

The results underscore the multifaceted nature of child musicality, extending beyond *musical abilities* (i.e., perception and production) to include *enthusiasm & motivation*, *musical communication* and *analytical understanding*. In infants and toddlers, *musical abilities*, *enthusiasm & motivation* and *musical communication* were replicated while *adaptive expressiveness* emerged as the fourth component, indicating age-related conceptual differences. The screening instrument based on these findings showed strong psychometric properties, indicating its potential for valid and reliable assessment of children's musicality.

This dissertation establishes an ecologically valid understanding of musicality that is informed by caregivers, educators and music professionals, who regularly observe children's musical behavior in real-life settings. Moreover, the developed screening tool enables research into individual differences in musical development and developmental trajectories. Together, these contributions facilitate the development of additional measurement tools that better capture the complexity of children's musical behavior. This work offers practical guidance for parents and educators on how to foster musical development.

Zusammenfassung

Obwohl kindliche Musikalität vielfältig und facettenreich ist, erfassen herkömmliche Messverfahren musikalische Fähigkeiten oft nur anhand isolierter, vorwiegend auditiver Aspekte. Dieser reduktionistische Ansatz beeinträchtigt die ökologische Validität der Messungen und erschwert ein nuanciertes Verständnis von Musikalität. Die Betrachtung von Musikalität als soziales Konstrukt, geprägt durch kulturelle Vorstellungen von Musik und Ästhetik, betont hingegen deren kontextabhängige und dynamische Natur. Demnach können die Beobachtungen von Eltern, pädagogischen Fachkräften und Musikexpert*innen, die Kinder in natürlichen Kontexten erleben, wertvolle Einblicke in die kindliche Musikalität eröffnen.

Diese Dissertation trägt dazu bei, die ökologische Validität von Musikalitätsmessungen zu verbessern, indem sie die Perspektive von Eltern, pädagogischen Fachkräften und Musikexpert*innen integriert. Ziel ist es, eine fundierte Grundlage für die Erforschung musikalischer Entwicklung zu schaffen, welche die Komplexität musikalischen Verhaltens abbilden kann. Studie 1 untersuchte Konzeptionen kindlicher Musikalität (3 bis 6 Jahre) im Vergleich zur Musikalität Erwachsener. Studie 2 erweiterte die Untersuchung auf das Säuglings- und Kleinkindalter und analysierte entwicklungsbedingte Unterschiede. In Studie 3 wurde ein kurzes Screening-Instrument für Eltern und pädagogische Fachkräfte zur Beurteilung kindlicher Musikalität (3 bis 10 Jahre) entwickelt. Es basiert auf einem weiten Verständnis des Konstrukts und wurde umfassend psychometrisch evaluiert.

Die Ergebnisse zeigen, dass kindliche Musikalität über *musikalische Fähigkeiten* im engen Sinne (Wahrnehmung und Produktion) hinausgehend auch *Enthusiasmus & Motivation*, *musikalische Kommunikation* und *analytisches Verständnis* beinhaltet. Bei Säuglingen und Kleinkindern wurden die ersten drei Komponenten repliziert, während *adaptive Ausdrucksfähigkeit* analytisches Verständnis ersetzte. Dies deutet auf entwicklungsbedingte Unterschiede in den Konzeptionen von Musikalität hin. Das in Studie 3 entwickelte Screening-Instrument zeigte gute psychometrische Eigenschaften, was auf sein Potenzial zur zuverlässigen Erfassung kindlicher Musikalität hinweist.

Diese Dissertation schafft die Grundlage für ein ökologisch valides Verständnis von Musikalität, basierend auf den Perspektiven von Eltern, pädagogischen Fachkräften und Musikexpert*innen, die das musikalische Verhalten von Kindern im Alltag beobachten. Das entwickelte Screening-Instrument ermöglicht die Erforschung individueller Unterschiede in der musikalischen Entwicklung, die Analyse von Entwicklungsverläufen und die Entwicklung von weiteren Messinstrumenten, welche die Komplexität musikalischen Verhaltens abbilden können. Darüber hinaus ergeben sich aus den Ergebnissen dieser Arbeit Ansatzpunkte zur Förderung der musikalischen Entwicklung durch Eltern und pädagogische Fachkräfte.

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I. SYNOPSIS

1 Introduction

From birth onwards—and even in the womb—babies are inherently musical, and rapidly develop surprisingly sophisticated abilities to perceive music (Trehub, 2003). These early music perception abilities are quickly followed by rudimentary forms of music production such as communicative babbling, spontaneous singing and rhythmic movement to music (Trehub, 2015). As they grow, children acquire more culture-specific and complex musical skills through enculturation and training (Sloboda, 1986/2008). Musical behavior in children is already remarkably diverse and rich; they sing, dance, make up songs, engage in musical play and enjoy their favorite tunes.

Despite the variety and complexity of children's musical behavior, most test procedures developed to assess musical development have primarily focused on aural perception (Hallam & Shaw, 2002). This emphasis became increasingly dominant in the mid-twentieth century as researchers, adhering to psychometric traditions, sought to quantify musical ability with the utmost precision and objectivity, relying on aural abilities as a measurable and replicable indicator (Gembris, 1997). However, the drive for scientific rigor, along with the view of musical aptitude as an unbiased, environment-independent predisposition, led to an oversimplification of musicality, ultimately compromising the ecological validity of the assessments. Furthermore, this reductionist approach assumes prior knowledge of the relevant conceptual dimensions (Christensen & Jola, 2015), but these had not been clearly established. In the following, conceptual ambiguity has led the test authors to prioritize those sub-competencies they already deemed fundamental and measurable (Gembris, 2017; Shuter-Dyson, 1999). Indeed, divergent views on which sub-competencies should be considered fundamental have contributed to inconsistent definitions, terminology[1], and test designs, resulting in varied psychometric outcomes and low validity of the existing measures (e.g., Degé et al., 2017; Demorest, 1995; Gembris, 2017; Hallam & Shaw, 2002; Schleuter, 1993). Since definitions shape the assessment procedures and are central to achieving validity, establishing a robust conceptual framework is a critical first step to improving the ecological validity of assessments.

Musicality is not a fixed natural category but a social construct shaped by societal and environmental factors. Since it is understood and experienced differently across cultures, groups and individuals (Blacking, 1971; Hallam & Prince, 2003), it should be studied within its specific social and cultural contexts. Recent research adopting this perspective suggests that conceptions of musicality in modern Western societies are multifaceted and encompass a wide range of skills that extend well beyond aural abilities (Hallam, 2010; Hallam & Prince, 2003). To gain a deeper understanding of

[1] Although the terms *musicality*, *musical ability*, *musical aptitude* and *musical talent* are often used interchangeably, *musical aptitude* or *musical talent* typically refers to innate musical potential. Throughout this work, *musicality* refers to a broader concept that includes emotional, cognitive and social engagement with music, while *musical ability* refers to specific skills such as pitch perception and rhythmic accuracy.

the conceptual dimensions of child musicality, insights from stakeholders—such as parents, educators and music professionals—offer valuable perspectives on children's musical behavior in natural settings, complementing findings from controlled scientific contexts. Their insights provide a more comprehensive view of children's musical development, which is essential for the development of ecologically valid assessments that capture everyday musical behaviors. This constructivist approach thus enables a more nuanced, culturally sensitive understanding of child musicality.

Building on this perspective, the following studies examine how caregivers[2], educators and music professionals conceptualize and assess child musicality based on their everyday observations of children's musical engagement. Study 1 (Buren et al., 2021a) investigated conceptions of child musicality in 3- to 6-year-olds, identifying differences among stakeholder groups and comparing these findings to those of a prior study of adult musicality (Hallam, 2010). Study 2 (Buren et al., 2021b) focused on conceptions of infant and toddler musicality (under 3 years), expanding the age range and providing insights into early developmental stages. Study 3 (Buren et al., 2025) centered on the development and validation of a musicality screening tool for children aged 3 to 10 years, designed as a questionnaire for parents and educators. Grounded in a broad social constructivist view of musicality, the tool offers a brief yet nuanced assessment of musical behaviors. Together, these studies deepen our understanding of children's musicality and mark a first step toward more ecologically valid assessments, laying the groundwork for further theory development and task design.

1.1 Development of musicality

Musical behavior is universal and every human has an innate, musical potential (Trehub, 2003), which begins developing in the womb and continues developing into adulthood (Trehub et al., 2019). Significant musical development occurs in childhood, driven by the effortless, unintentional acquisition of culture-specific musical competence—known as enculturation—and by intentional, focused training (Gooding & Standley, 2011; Hannon & Trainor, 2007). By the time babies are born, they already possess refined perception abilities (Gooding & Standley, 2011; Trehub, 2006a) and culturally universal musical competence (Trehub, 2006b). During the first months of life, these abilities allow infants to perceive subtle changes in music of any culture (Trehub, 2015). By around one year of age, they begin to exhibit specialized culture-specific responses to the musical environment of their own culture (Hannon & Trehub, 2005; Trehub, 2015). At about the same time, children increasingly engage in musical activities, exhibiting rudimentary dancing (Trehub, 2015) and early singing (Stadler Elmer, 2012a). Infants and toddlers are typically drawn to musical stimuli (Trehub, 2003) and are highly motivated to engage in musical interactions with their caregivers by

[2] Throughout this work, the term *caregiver* refers to primary caregivers, including parents and those who take on a parental role, such as guardians, relatives, or other individuals responsible for a child's upbringing.

providing matched expressive responses and these interactions, consequently, turn into cooperative forms of (musical) communication (Flohr & Trevarthen, 2008). Caregivers, in turn, often use music to soothe or to play with their children (Cirelli, Jurewicz & Trehub, 2020; Trehub & Gudmundsdottir, 2015; Trehub & Trainor, 1998) and thus shape the musical environment of infants with their own musical practices (Ilari, 2018) as well as their goals and beliefs about musical development (Ilari, 2005). As children grow older, they become increasingly musically active and start incorporating music into their everyday play (Cirelli, Peiris, et al., 2020). Enculturation remains the main driver of musical development in their early years, complemented by training, when the children enter kindergarten or school and potentially begin formal music lessons. Enculturation is typically considered complete by the age of 10 to 12 years (Degé & Roden, 2018; Sloboda, 1986/2008); by this time, many basic music-related competencies are so well developed that they resemble those of untrained adults (Cohrdes et al., 2018). However, musical development continues throughout adolescence (Müllensiefen et al., 2022) and into adulthood, where it becomes increasingly heterogeneous as musical involvement diversifies (Degé, 2025).

While research on musical development has established age-related milestones in musical ability acquisition, the understanding of individual differences remains limited (Stadler Elmer, 2012b). Furthermore, the tendency to examine specific abilities in isolation, without considering their relationship to the broader concept of musicality, can lead to fundamental dimensions of musicality being neglected. This, in turn, reduces the ecological validity of the findings and prevents research from fully capturing the causes, contexts and key associations underlying the emergence of skills (Forrester & Borthwick-Hunter, 2015). Beyond the conceptual limitations mentioned, ecological validity is also influenced by the experimental setting, the stimuli used and the nature of the task or required responses (Schmuckler, 2001). Recent studies observing children's musical behavior in more natural contexts suggest their abilities may be underestimated in laboratory-based research. This is evidenced by comparisons of free dance behavior between home- vs. lab-based observations (Eerola et al., 2006; Kragness et al., 2022) and also research on singing that found higher proficiency and pitch range in home recordings (Gudmundsdottir & Trehub, 2017). To address these limitations, recent studies have examined children's responses in simulated natural environments such as concerts (Kragness, Berezowska & Cirelli, 2023; Kragness, Eitel, et al., 2023) or applied detailed qualitative analyses of complex behaviors in culturally embedded contexts (Stadler Elmer, 2011, 2012a, 2012b).

As seen, musical behaviors and abilities are diverse and vary among individuals, yet research has typically focused on identifying age-related milestones, often by employing controlled environments, simplified stimuli and narrowly defined tasks. While this improves experimental control, it

can also lead to an underestimation of children's abilities and to fragmented findings that are difficult to integrate into a coherent understanding of musical development.

1.2 Approaches to measuring musicality

To better understand musical development and to complement assessments of specific abilities, researchers use tests and questionnaires to evaluate musicality as a whole. For these measures to be ecologically valid, they must encompass a broad range of behaviors that qualify as "musical". However, traditional measures have primarily focused on limited indicators of musical aptitude, focusing primarily on basic aural skills, which were long considered independent of training, experience, culture and aesthetic norms (Gembris, 1997). Emotional and motivational factors, by contrast, were largely neglected (Gembris, 1997). This bias stems partly from historical research traditions that shaped how musicality has been studied and measured.

Historically, three broad phases in musicality research can be identified (Gembris, 1997): a phenomenological approach (1800–1910/20), a psychometric approach (1920s–present), and a musical meaning approach (1980–present). The psychometric approach, dominant in the mid-20th century and still influential today, aimed for objective, unbiased assessments and led to the development of several well-known musical aptitude tests for children (Gembris, 1997; Grashel, 2008). One of the earliest tests is Seashore's *Measures of Musical Talent* (Seashore, 1919), designed to identify highly gifted students. Based on a multi-factorial model, these measures rely on basic sensory discrimination tasks to generate a profile of musical abilities (Seashore, 1938/1967). In contrast, Bentley's *Measures of Musical Abilities* (Bentley, 1966) adopt a general factor model, providing an overall score based on tasks such as pitch discrimination, rhythmic memory and chord analysis. The widely used *Gordon tests* (Gordon, 1965, 1979, 1982, 1989a, 1989b) emphasize audiation: the capacity to hear, feel, and comprehend music internally. Despite criticisms of their narrow focus (Colwell & Abrahams, 2021; Hallam & Shaw, 2002; Woodford, 1996), these tests remain influential (Cutietta, 2021) with several versions spanning childhood and adolescence (ages 3 to 17 years). More recent tests (e.g., Law & Zentner, 2012; Ullén et al., 2014; Wallentin et al., 2010) continue to emphasize perceptual skills, often using simple, abstract stimuli, thereby reinforcing the focus on basic auditory processing over authentic conceptions of musicality.

Despite their influence, these tests have been criticized for inconsistent definitions of musicality, which often reflect the theoretical assumptions of individual researchers and hinder the development of valid assessment tools (Ollen, 2006; Shuter-Dyson, 1999). In addition, highly standardized perception tasks with artificial stimuli and unnatural task requirements limit the ecological validity of assessments (e.g., Demorest, 1995; Gembris, 2017; Hallam & Shaw, 2002; Schleuter, 1993); this is reflected in their low prognostic validity as many tests fail to predict broader musical outcomes,

such as musical performance (Manturzewska, 1990; Norton et al., 2005; Winner & Martino, 2003). To address these limitations, some researchers have called for a shift toward the study of complex, culturally embedded behaviors (Murphy, 1999; Stadler Elmer, 2011, 2012a, 2012b). This requires definitions that account for the diverse ways in which musicality manifests across experiences, practices and contexts (Levitin, 2012; Sloboda, 2008). More recently, efforts have focused on developing more inclusive models and assessment tools that capture a wider variety of musical behaviors (Hallam & Prince, 2003; Levitin, 2012; Müllensiefen et al., 2014; Murphy, 1999) aiming to reflect, more adequately, how music is actually experienced (Sloboda, 2008).

1.3 Conceptions of musicality

Musical aptitude is universal, varies across individuals and is assumed to be normally distributed within the population (Gembris, 2018), similar to other complex constructs like intelligence (Cutietta, 2021). Since around the early 21st century, there have been growing efforts to develop a more ecologically valid and integrated understanding of musicality (e.g., Hallam, 2010; Hallam & Prince, 2003; Levitin, 2012; Müllensiefen et al., 2014; Murphy, 1999). Broadly speaking, these efforts have followed two complementary research approaches. The first, a social constructivist approach, emphasizes ecological validity by exploring conceptions within the general population, to refine the theoretical foundation of the construct. The second approach is empirical-quantitative and focuses on developing instruments that capture a wider variety of musical behaviors. Typically, their development begins with compiling a comprehensive item pool that is then refined through data collection and analysis (see, for example, Müllensiefen et al., 2014). This process supports the development of assessment tools that are both scientifically rigorous and practically relevant.

The social constructivist approach does not view musicality as an objective entity but rather as a social and cultural construct shaped by cultural understandings of music and aesthetics (Gembris, 1997). The skills required for music production and appreciation differ accordingly, which in turn influence conceptions of musicality (Gembris, 1997, 2017). These conceptions develop through societal negotiation and can vary across cultures, groups and individuals (Blacking, 1971; Hallam & Prince, 2003) reflecting musical traditions, preferences and values (Gembris, 2017; Trehub et al., 2015). Examining these conceptions within the general population and across various stakeholders—such as caregivers, educators and music professionals—reveals how musicality is understood in specific cultural and historical contexts. Studies on conceptions of adult musicality have revealed a broad understanding that includes aural skills, generative activities, musical communication and personal factors such as motivation and commitment to music (Hallam, 2010; Hallam & Prince, 2003). Notably, professional musicians placed the greatest emphasis on musical communi-

cation, whereas educators highlighted creativity. In contrast, both amateur musicians and non-musicians focused more on aural skills and motivation (Hallam, 2010). While these studies focused on musicality in adults, conceptions of children's musicality remain largely unexplored.

Several measurement tools have been developed using empirical-quantitative approaches to capture musicality more comprehensively across various facets. The Gold-MSI (Goldsmiths Musical Sophistication Index) captures individual differences in musical engagement (referred to as musical sophistication) within the general population, moving beyond the musician vs. non-musician dichotomy (Müllensiefen et al., 2014). This self-report questionnaire incorporates facets such as *active engagement*, *music training*, *singing abilities* and *emotional response* (Müllensiefen et al., 2014); a corresponding self-report tool for children, the Child Musicality Index, is under development (MacGregor et al., 2025). For younger children, parent-report questionnaires are used. For instance, the Music@Home questionnaire assesses children's musical behavior in the home environment for infants and preschoolers, covering dimensions such as *parental beliefs*, *child engagement* and *parent-initiated activities* (Politimou et al., 2018). The scale was developed by reviewing existing questionnaires, gathering qualitative input from parents, and using factor analysis to identify dimensions and to reduce the item pool. Similarly, the Children's Music-Related Behavior Questionnaire (Valerio et al., 2012) was developed based on a review of qualitative and quantitative research. Parent focus groups helped to refine the initial item pool, resulting in in a 97-item version assessing musical behaviors such as *vocalizations*, *movement*, *creativity*, and *parent music activities* in children up to 5 years of age. Both tools provide valuable insights into the musical home environment and parent-child interactions; however, they primarily assess children's musical engagement with their caregivers, rather than musicality as a distinct construct. In educational settings, the KOMPIK (Mayr et al., 2012) provides a broader assessment of *musical competencies and interests* in children aged 3.5 to 6 years. It was developed based on educational frameworks and expert consultations and its validity and reliability have been evaluated for use in professional settings (Krause, 2017).

While these tools illustrate some progress in the field of child musicality research, there is still a lack of tools to assess child musicality as a distinct construct. Similarly, little is known about conceptions of child musicality in the general population, as prior studies have focused on adult musicality. This gap in theory and assessment of child musicality has hindered a more comprehensive understanding of musical development.

1.4 Objectives

To fill this gap and to enhance the ecological validity of research on child musicality, the present studies adopted a social constructivist approach, viewing musicality as a socially and culturally shaped construct. This perspective ensures that the assessments reflect natural musical behaviors

rather than abstract or narrowly defined criteria. By incorporating the perspectives of key stakeholders—such as caregivers and educators—who regularly observe and engage with children in musical contexts, the following studies explored the conceptions of musicality within the general population, focusing on children, toddlers and infants. The insights gathered from these stakeholders informed the development of a brief screening tool designed to capture musicality as it naturally unfolds in everyday interactions. Study 1 (Buren et al., 2021a) investigated conceptions of musicality in children aged 3 to 6 years. Building on previous research on adult musicality (Hallam, 2010), it was the first to explore, systematically, how child musicality is conceptualized, incorporating insights from educators, caregivers and music professionals (musicians and music educators). The study examined differences in conceptions across these groups and compared them to conceptions of adult musicality. Study 2 (Buren et al., 2021b) extended this investigation to infants and toddlers under 3 years, exploring whether conceptions of musicality change with age. Study 3 (Buren et al., 2025) developed and evaluated a screening tool in German and English to assess musicality in children aged 3 to 10 years, based on a broad understanding of the construct, derived from the first two studies. These studies provide valuable insights into musical development in ecologically valid contexts and have important implications for future research as well as music education, encouraging deeper discourse.

2 Study 1: Conceptions of child musicality

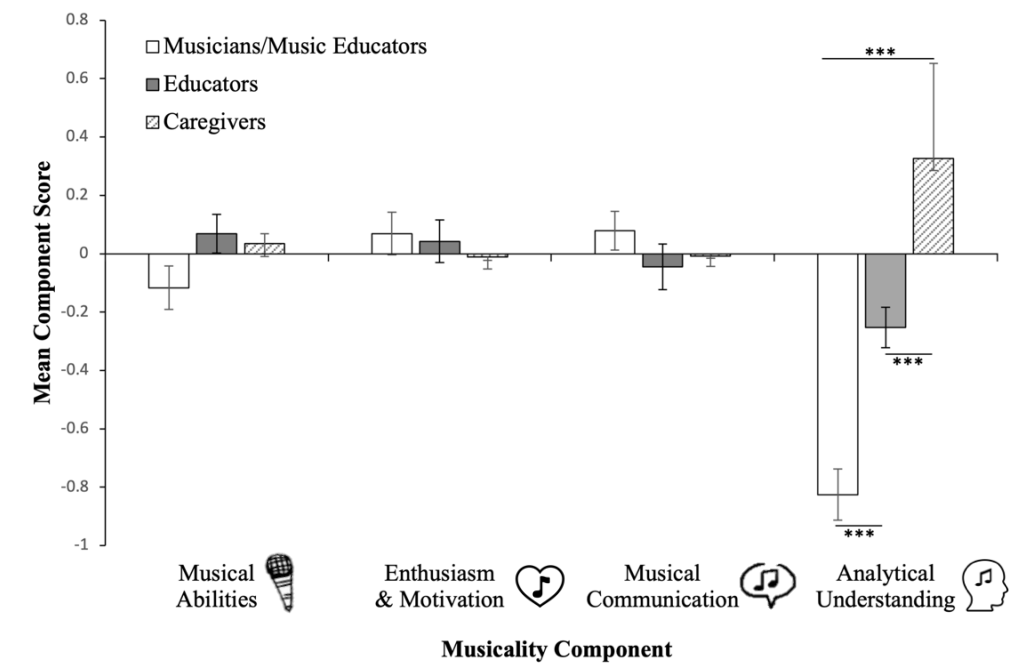
Introduction. While previous research on musicality in children has primarily focused on isolated abilities, particularly aural skills (for reviews, see Hallam, 2006; Shuter-Dyson, 1999), less is known about how child musicality is perceived in everyday contexts. Since musicality is socially constructed, *lay conceptions*—insights from caregivers, educators and music professionals—are particularly relevant to understanding the construct. Moreover, as these individuals engage with children in musical interactions, they can provide ecologically valid perspectives. Study 1 examined conceptions of child musicality, explored group differences among stakeholders, and investigated their relation to conceptions of adult musicality. Understanding these perspectives can help clarify the construct and support the development of more appropriate and comprehensive measures.

Methods. To this end, statements from previous research on how different stakeholders conceptualize musicality, i.e., their understanding of what musicality is (Hallam, 2010; Hallam & Prince, 2003), were translated and adapted to be suitable for younger age groups. The modifications involved simplifying items and removing those that were either developmentally inappropriate or redundant. In an online study, German-speaking participants who regularly spent time with children (caregivers, educators and musicians/music educators), rated the remaining 49 statements on a Likert scale. To explore what they consider indicative of musicality, they assessed how often a hypothetical musical child between the ages of 3 and 6 years (not a specific child they knew) would typically

show such behaviors. In addition, participants provided demographic information as well as details about their professional and musical backgrounds.

Results. Principal component analyses (PCA) revealed four components of child musicality: *musical abilities*, *enthusiasm & motivation, musical communication* and *analytical understanding*. Notably, *enthusiasm & motivation* received the highest mean ratings among the four components. Moreover, a comparison of mean component scores across the stakeholder groups showed that only *analytical understanding* was rated differently: While caregivers considered it indicative of musicality, educators placed less emphasis on it and musicians rated it as being least important (see Figure 1). This suggests that different groups within a culture can indeed hold distinct views on the significance of certain facets of musicality. However, compared to previous studies on conceptions of adult musicality (Hallam, 2010; Hallam & Prince, 2003), these differences were less pronounced. Another key difference from previous research was the number of identified components; while six components were found for adult musicality (Hallam, 2010), only four emerged for child musicality.

Figure 1. *Mean Component Scores across Stakeholder Groups.*



Note. Component scores were computed using regression and analyzed with MANOVA, revealing a significant effect of professional background. Univariate ANOVAs showed significant differences only for *analytical understanding*. Error bars represent the standard error of the mean. Adapted from Buren et al. (2021a).

***$p < .001$

In summary, Study 1 provides evidence for a broad conception of child musicality in the general population. The component *musical abilities* encompasses both perception and production skills, while the three remaining components—*enthusiasm & motivation, musical communication* and *analytical understanding*—reflect the nuanced perspectives of the stakeholders. These conceptions are

considerably broader than what most tests of musicality assess and represent an ecologically valid understanding of how musicality is understood. The participants largely agreed on the considerable importance of *enthusiasm & motivation* as being integral to musicality while their assessment of *analytical understanding* varied depending on their professional background. Compared to adult musicality, child musicality comprises fewer components, suggesting that conceptions of musicality vary with age and developmental progress. If conceptions of musicality are shaped by development, exploring how musicality is perceived in even younger children is particularly relevant.

3 Study 2: Conceptions of infant and toddler musicality

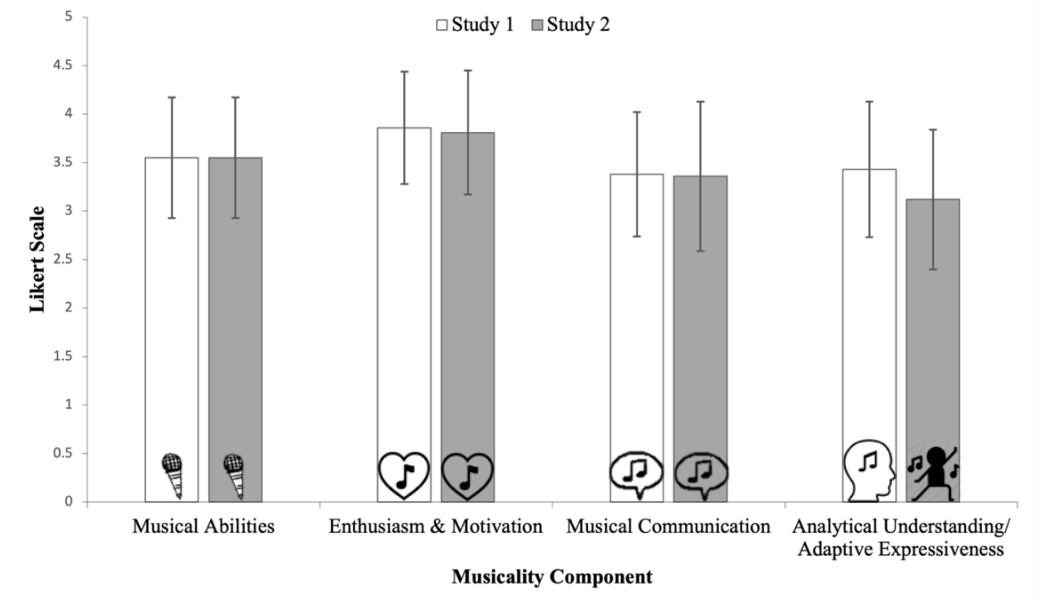
Introduction. Younger children and infants undergo rapid development across both musical and general domains such as motor skills, language and social development, all of which impact their ability to engage with music (Degé, 2025). Considerable research in these age groups has focused on specific aspects of musical development, such as rhythm, tempo and pitch perception, as well as, to a lesser extent, music production. However, relatively little progress has been made in integrating these findings into a unified understanding of infant and toddler musicality. Given the variety of musical experiences in early childhood, caregivers and early childhood educators likely perceive musicality in infants and toddlers as rich and multifaceted. The aim of Study 2 (Buren et al., 2021b) was to explore how different stakeholders, specifically caregivers and educators, conceptualize musicality in children under 3 years of age, and to examine whether the conceptions of musicality identified in Study 1 extend to younger age groups. Understanding how caregivers and educators perceive musicality in younger children provides insights into specific characteristics of musicality in early years and reveals how conceptions of musicality evolve with age. In the long term, these findings can help develop assessments for infants and toddlers and promote more holistic approaches to fostering musicality in early education.

Methods. In an online study, German-speaking caregivers and educators who regularly interacted with children under the age of 3 years rated 41 statements covering musical behaviors, adapted from Study 1. Items from Study 1 were modified or removed to ensure age-appropriateness. Respondents rated these statements based on their perception of how often a hypothetical musical child under 3 years old would exhibit these behaviors, aiming to identify key indicators of musicality for this age group. In addition, they answered questions about their personal, professional and musical backgrounds.

Results. PCA analysis again revealed 4 components of musicality: *musical abilities, enthusiasm & motivation, musical communication* and *adaptive expressiveness*. The number and structure of the components largely mirrored those found in Study 1. Consistent with previous findings, *enthusiasm & motivation* received the highest mean score among all components. However, a notable difference

emerged: the component *analytical understanding*, identified in Study 1, was absent in this conception. Instead, another slightly different component, *adaptive expressiveness*, was extracted. This component describes how infants and toddlers adjust their expressive reactions in response to various aspects of music (see Figure 2 for a comparison of the mean ratings, grouped by components, between Study 1 and 2). This suggests that, while younger children may not yet demonstrate understanding through verbalized analytic reasoning, a similar mechanism could still be at work, evident in their non-verbal, intuitive responses to music. Another key distinction from Study 1 was that conceptions held by professional educators did not significantly differ from those of caregivers.

Figure 2. *Mean Ratings by Musicality Components in Studies 1 and 2.*



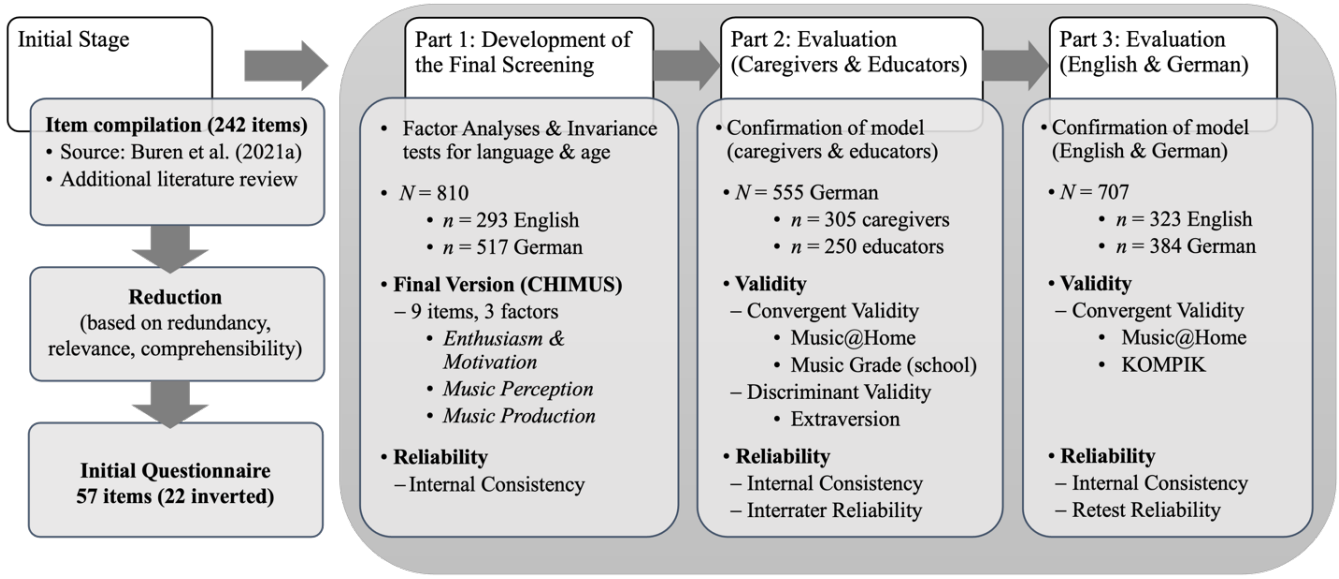
Note. Error bars represent standard deviations. Ratings were given on a 5-point Likert scale.

Taken together, Study 2 confirmed that the multifaceted nature of musicality is also reflected in conceptions of infant and toddler musicality. While the identified components were similar to Study 1, they were not identical: *analytical understanding* was absent while *adaptive expressiveness* emerged. This shows that conceptions of musicality can vary according to the age group being studied, reflecting the influence of general development. Despite these differences, the consistency in the remaining components suggests a stable conceptual framework for musicality across age groups, particularly regarding *musical abilities* (perception and production), *enthusiasm & motivation* and *musical communication*. The prominence of *enthusiasm & motivation*, which received the highest mean score in both studies, further underscores its central role in musicality. Together, these findings highlight the complexity and relevance of child musicality conceptions and emphasize the need to integrate these facets into assessments to ensure that measurements accurately capture real-life musical behaviors, thereby enhancing their ecological validity.

4 Study 3: Development and validation of the Child Musicality Screening

Introduction. The first two studies explored the conceptions of musicality by asking respondents to rate statements based on their assessment of a musical child, without prompting them to think of a specific child. The findings provided valuable insights into how different stakeholders, who regularly interact with children in the respective age group, perceive musicality. However, conceptual considerations alone are not enough. In both scientific and educational practices, measurement tools are necessary for observing, exploring, and understanding musicality and its development, as well as for testing and refining theories and hypotheses. While several tools for assessing musical development exist, each of them comes with limitations, such as a narrow scope, limited scientific rigor, or poor user-friendliness (e.g., being overly long or complex). To assess musicality comprehensively and efficiently, researchers and practitioners need a tool that is both grounded in empirical evidence and aligned with the stakeholder conceptions of children's musicality. Study 3 (Buren et al., 2025) addresses this need by developing a short screening tool for children aged 3 to 10 years. The questionnaire is available in both German and English and is designed to be completed by caregivers and educators. Study 3 consisted of 3 parts: the development of the questionnaire (Part 1) and its psychometric evaluation (Parts 2 and 3; see Figure 3).

Figure 3. *Overview of the Parts of Study 3.*



Part 1: Development and Structural Validation of the Child Musicality Screening. The development of the questionnaire in Study 3, Part 1, followed a structured, multi-step process. First, a large item pool was generated, drawing from the items used in Study 1 and supplemented with relevant items from the literature. This pool was refined by removing redundant, unclear or irrelevant items, resulting in a set of 57 items. The questionnaire was administered online in both English and

German, along with questions on the participants' backgrounds. Participants—adults who regularly interacted with children in the relevant age range—completed the questionnaire while keeping a specific child in mind. In the next phase, the item set was further reduced using factor analyses and tests for language and age group invariance. This process resulted in the final 9-item questionnaire, the Child Musicality Screening (CHIMUS), which consisted of 3 (substantially correlated) factors: *enthusiasm & motivation*, *music perception* and *music production*. The final version demonstrated scalar invariance across both languages and age groups (3–6 vs. 7–10 years), ensuring its applicability across different populations.

Part 2: Reliability and Validity in Caregiver and Educator Ratings. Part 2 explored the reliability (internal consistency and interrater reliability) as well as the validity of the screening tool in a separate German-speaking sample of caregivers and educators through a paper-based assessment. The confirmatory factor analysis (CFA) results indicated a good model fit for the educator group and an acceptable fit for the caregiver group. Internal consistency was high in both groups, with stronger reliability observed in the educator group. Interrater correlations between caregiver and educator assessments were moderate but statistically significant. Convergent validity was supported by positive correlations with the child's most recent music grade and the Music@Home general factor (Schaal et al., 2020). Divergent validity was demonstrated by non-significant correlations with two measures of extraversion, indicating that the screening specifically assessed musicality rather than a personality trait associated with a greater tendency to display musical behavior in social situations.

Part 3: Reliability and Validity of the English and German versions. Part 3 explored the test-retest reliability and provided a more detailed analysis of convergent validity for both the English and German versions of the questionnaire. To this end, an online study was conducted in both languages and supplemented by paper-based testing in the German sample. Results indicated an acceptable to good model fit for the German data and an excellent fit for the English data. Internal consistency ranged from moderate to very good. Test-retest reliability over two weeks was notably high for both language versions, indicating the stability of the instrument over time. Convergent validity was supported by moderate to strong correlations with the Music@Home measure (Politimou et al., 2018; Schaal et al., 2020) and by very strong correlations with the KOMPIK *musical competencies and interests* scale (Mayr et al., 2012). Divergent validity was supported by non-significant correlations with two measures of extraversion.

In summary, Study 3 developed and thoroughly evaluated the Child Musicality Screening, a short screening tool for musicality, based on a broad conception that encompasses a wide range of musical behaviors and supports ecological validity by reflecting children's real-life experiences. The

tool underwent extensive validation across multiple testing phases, including factor analysis, language and age group invariance testing, and analyses of internal consistency, interrater reliability and convergent validity. The final 9-item questionnaire measures *enthusiasm & motivation*, *music perception* and *music production*. The evaluation confirmed that the tool is applicable in German and English and can be used by caregivers and educators. While caregiver ratings appeared less accurate than those of educators, the results suggested that the tool still effectively captures child musicality. Reliability and validity analyses provided promising evidence, indicating that the screening can reliably assess musicality in children aged 3 to 10 years in English and German, thus offering a psychometrically sound and versatile measure.

5 Discussion

This dissertation aimed to advance the understanding of musicality in young children, with a particular emphasis on representing real-world musical behavior to strengthen the ecological validity of both conceptions and assessments. By adopting a broad perspective, the included studies move beyond reductionist assessments of isolated abilities or reliance on singular theoretical frameworks. Instead, they integrate conceptions from key stakeholders in child musicality, i.e., caregivers, educators and music professionals. This approach extends previous research in adult musicality (Hallam, 2010; Hallam & Prince, 2003) by addressing the distinct characteristics of child musicality, exploring age-related differences and highlighting the importance of assessments that reflect children's natural musical expressions.

Study 1 (Buren et al., 2021a) showed that, in modern Western contexts, child musicality is perceived as a combination of *musical abilities* (perception and production), *enthusiasm & motivation*, *musical communication* and *analytical understanding of music*. These findings suggest that conceptions of child musicality differ from those of adult musicality in that they include fewer factors while still maintaining a multifaceted structure. Study 2 (Buren et al., 2021b) built on these findings by examining conceptions of musicality in infants and toddlers. Results indicated a similar multifaceted structure but also showed that conceptions vary depending on developmental stage. These findings highlight the importance of age-appropriate assessments. Overall, both studies emphasize the complexity of musicality and underscore the need for inclusive assessments that reflect real-life musical experiences. Study 3 (Buren et al., 2025) addressed this need by introducing the first thoroughly evaluated short screening tool for parents and educators of children aged 3 to 10 years. The tool, which assesses *enthusiasm & motivation, music perception*, and *music production*, allows researchers and practitioners to conduct a brief yet comprehensive assessment of children's musicality.

In summary, these studies show that child musicality is broad and multifaceted, with *enthusiasm & motivation* as an integral feature. Thus, moving toward ecological validity in child musicality research involves adopting these broader conceptions and considering a wide range of behaviors when assessing child musicality. This perspective aligns with the social constructivist approach and fosters a more nuanced, ecologically valid understanding of musical development.

5.1 What does it mean to be musical?

An ecologically valid approach acknowledges musicality as a socially constructed phenomenon. Exploring lay conceptions therefore promotes a more holistic understanding of child musicality. This aligns with research emphasizing that a theory of musicality should account for its various manifestations (Levitin, 2012). While simplifications may be useful initially, research should then move toward more ecologically valid approaches (Sloboda, 2008). Moreover, a social constructivist perspective recognizes that conceptions of musicality are inherently tied to cultural contexts and prevailing societal notions of music (Hallam & Prince, 2003). While cultural specificity may limit generalizability, it also allows evolving forms of musicality to be acknowledged, fostering a more dynamic and authentic understanding.

This view has been challenged by researchers who argue that a strong focus on ecological validity leads to heterogeneous constructs that hinder the investigation of a phenomenon, thus compromising construct validity (Karma, 2007). Another concern is that lay conceptions may be shaped by prevailing "folk views"—assumptions that influence evaluations of musicality. These include beliefs about the heritability of musical talent and the perceived (lack of) malleability of musical abilities (Sloboda et al., 1994). For example, many adults perceive themselves as "tone-deaf", despite evidence that musical talent is normally distributed (Sloboda, 2008). However, the findings of the studies included in this dissertation showed no clear evidence of such biases, as conceptions were multifaceted and measurements showed no signs of dichotomous judgements on musicality. Nevertheless, these concerns should be considered when researching lay conceptions.

Especially in the study of lay conceptions, the composition of the study sample can play a pivotal role in shaping findings. In Studies 1 and 2, the self-selected sample was predominantly highly educated and female. Moreover, participants likely had a strong interest in musical development and frequently interacted with children. While this ensured well-informed and relevant conceptions, it may also have introduced a certain degree of homogeneity, which may have overlooked variations within cultural conceptions of musicality. Previous research has shown differences in how adult musicality is conceptualized (Hallam, 2010; Hallam & Prince, 2003). In child musicality, however, the only significant group difference observed in Studies 1 and 2 was in the evaluation of

analytical understanding in Study 1. Differences in how caregivers, educators and music professionals rated this facet underscore the potential influence of personal and professional backgrounds on conceptions of musicality. Including a more diverse sample may reveal additional variation and provide a richer, more nuanced picture of how child musicality is perceived.

Studies 1 and 2 showed that conceptions of musicality differ not only between child and adult musicality but also across age groups within childhood: Compared to child musicality, conceptions of adult musicality appear to be more differentiated (Hallam, 2010; Hallam & Prince, 2003), likely due to the increased specificity and diversity of musical engagement and skills in adults (Degé, 2025). Within childhood, Study 2 showed that *adaptive expressiveness* in infants and toddlers is later in childhood replaced by *analytical understanding*, suggesting that conceptions of musicality change as children develop. However, the broad age ranges used in Studies 1 and 2 may have masked finer developmental distinctions. While employing narrower age brackets in future research may yield more detailed insights, it is recommended that the age ranges remain broad enough to capture truly distinct conceptions of musicality and avoid overly fragmented or redundant comparisons.

Enthusiasm & motivation emerged as a key component of musicality in both infancy and childhood. This likely reflects the awareness of the participants that intrinsic motivation is foundational for the development of musical skills. A high level of motivation can affect both the quality and quantity of children's engagement with music (McPherson & Williamon, 2006). Enjoyment and intrinsic motivation likely stem from pleasurable musical experiences, thus fostering a personal commitment to music (Sloboda et al., 1994). However, genetic factors associated with musical sensibility may also play a role (Hansen et al., 2024). Furthermore, personality traits, such as openness-to-experience have been linked to musical engagement (Corrigall et al., 2013; McManus & Furnham, 2006), highlighting the complex interplay between innate predispositions and environmental influences. Together, these findings suggest that motivation serves both as a driver and a prerequisite for the development of musical abilities throughout childhood.

5.2 How can musicality in childhood be assessed?

Assessing musicality in an ecologically valid way is essential to fully understand children's musical abilities and development. Rather than drawing conclusions from sample averages or piecing together fragmented findings from studies on isolated musical abilities, a holistic approach can provide a richer, more nuanced understanding of musical development. Levitin (2012) argues that the best way to explore musicality is to consider and assess as many musical behaviors as possible rather than focusing on isolated specific abilities. This is particularly important in childhood, when multiple abilities are still developing. Studying conceptions of musicality is especially valuable in this context. It allows for a broad perspective while also identifying the facets that are most relevant

in real-life settings, which ensures practical applicability. Study 3 built on Studies 1 and 2 to translate theoretical insights into a practical assessment tool. This led to the development of the Child Musicality Screening, which is the first brief, empirically grounded questionnaire of child musicality. Unlike other tools, such as the Music@Home Scale (Politimou et al., 2018), which focuses on the home environment, or the Children's Musical Behavior Questionnaire (Valerio et al., 2012), which is lengthy and time-consuming, this screening provides a concise and focused alternative for assessing children's musicality, and can thus be easily incorporated in developmental studies as a covariate or control variable. The tool has been validated for the use by educators and parents. As experts on their own children, parents have been shown to provide reliable information about their children's cognitive, social and emotional development (e.g., Bodnarchuk & Eaton, 2004; Glascoe, 1999; Squires et al., 2001) and have been used to gain insights into musical behaviors (e.g., Custodero et al., 2003). Due to the parents being intimately familiar with their children's behavior in everyday contexts, such as the home environment, they can reveal richer and more diverse behaviors than those observed in laboratory settings (e.g., Eerola et al., 2006; Kragness et al., 2022), improving the ecological validity of assessments. Educators can offer unique perspectives, since they observe a diverse group of children and can compare their behaviors. In Study 3, educator ratings were more consistent and reliable; this was probably due to their pedagogical expertise which may have fostered greater objectivity. In contrast, parents tended to rate their children more positively, possibly due to a natural bias towards their child or lack of comparative benchmarks which is common in the parental assessments of a child's competencies. Correlations between educator and parent ratings of the same child were moderate but highly significant, indicating that, despite these differences, both groups' assessments were reasonably well-aligned and reflected a shared understanding of the child's musicality.

Nevertheless, the screening also has limitations. Its brevity restricts its potential to capture comprehensively all the facets of musicality, and it does not fully reflect the dimensions identified in Study 1. Although *musical abilities* and *enthusiasm & motivation* were present in the conceptions, as well as in the screening, the facets *musical communication* and *analytical understanding* were not included in the screening. These discrepancies may stem from the difference in focus: Studies 1 and 2 asked about a hypothetical musical child, which likely prompted more intangible and idealized conceptions of musicality. In contrast, the screening focused on observable behaviors in everyday contexts. Thus, if certain characteristics are rarely present, observed or recognized in a broad sample of children, they are less likely to be included. The absence of concepts like *musical communication* and *analytical understanding* may stem from the challenges of observing complex or abstract aspects of musicality. Moreover, caregivers who do not engage frequently in musical interactions with their

children may find it challenging to identify or evaluate these nuanced aspects. Furthermore, the broad age range used in the development of the screening could have led to less specific factors, as the items selected needed to be applicable across different developmental stages. These challenges shed light on the trade-offs between efficiency and comprehensiveness in questionnaire design. Moreover, cultural specificity remains a limitation since behaviors considered musical in one cultural context may not be recognized as such in another, thus limiting the tool's applicability across diverse cultural settings.

Regarding the factors assessed by the Child Musicality Screening, the *music perception* factor aligns with traditional approaches to assessing child musicality, reinforcing its relevance. Its classification as a separate factor is justified, considering that the relation between music perception and production abilities remains unclear (Levitin, 2012), although it has been suggested that music perception may be foundational for music production (Cohrdes et al., 2018). The *music production* factor, in turn, highlights the importance of incorporating music production tasks into comprehensive assessments of musicality. However, the production scale showed the lowest psychometric values; this was possibly due to the inclusion of negatively worded items during factor analysis. This suggests that difficulties in the execution of music production may be more salient and easier to assess than proficiency. Despite these challenges, incorporating both perception and production provides a more holistic understanding of musicality and strengthens the ecological validity of assessments. The inclusion of *enthusiasm & motivation* aligns with findings from Studies 1 and 2, where this factor emerged as being central to musicality. While some researchers (e.g., Karma, 2007) suggest that musical motivation may be short-lived, the high test-retest reliability observed for *enthusiasm & motivation* in Study 3 suggests its stability over at least two weeks. This is consistent with the idea that musical motivation develops over a long time through pleasurable musical experiences and may therefore be relatively stable (Sloboda et al., 1994). In addition, environmental factors, such as parental beliefs and behaviors, play a crucial role in fostering children's enthusiasm and motivation (McPherson, 2009). These findings highlight the importance of considering environmental influences alongside individual factors when assessing musical motivation.

5.3 How can musicality be promoted?

The present results also offer avenues for the promotion of musicality. To support children's musical development effectively, it is crucial to understand what musicality encompasses, which aspects can be nurtured, and how. Even when not explicitly stated, conceptions of musicality are implicitly embedded in music education concepts and curricula (Gembris, 2017). Consequently, educational activities are more likely to be planned for musical abilities that a teacher recognizes and

considers worth teaching (Degé, 2025). A narrow definition of musicality combined with rigid assessment criteria and the view of musicality as innate, can have a strong and potentially damaging impact on music education (Murphy, 1999). It may restrict teaching approaches and influence the level of support a child receives, ultimately shaping their musical development. Moreover, assessments often reflect the subjective opinions of music educators and instrumental teachers making objectivity challenging (Gembris, 2017). In this context, adopting a broader and more ecologically valid perspective can help ensure that assessments and instructional approaches better reflect and support children's diverse musical experiences. This dissertation addresses these challenges by proposing a more inclusive, empirically grounded framework.

Studies 1 and 2 take a broader perspective on musicality by framing it as a social construct. They identify key components that can inform music education and extend beyond traditional aspects such as music perception and production. These include *enthusiasm & motivation*, *musical communication* and *analytical understanding*, offering multiple pathways for supporting children's musical development and fostering a more inclusive approach to music education. Beyond technical skills, the findings highlight the importance of enthusiasm and motivation, both of which are essential for acquiring musical skills (Trehub et al., 2019). Study 3 introduces a screening tool that provides a more holistic assessment of musical development. Unlike traditional assessments that often focus on identifying especially gifted students, this tool enables a broader evaluation: It helps identify areas for growth and track progress over time. A deeper understanding of musicality allows teachers to adapt their methods to specific students and situations (Sloboda 1986/2008). The ultimate goal should be to provide all children with tailored support that allows them to engage with and enjoy music in their own unique way and experience it as a valuable lifelong source of enjoyment (Trehub et al., 2019).

An environment where music is appreciated and enjoyed plays an important role in fostering the development of musicality (Shuter-Dyson, 1999). Parents contribute significantly by creating a diverse, musically-enriched environment, supporting the child's interests, and teaching culturally specific musical knowledge and skills (Ilari, 2018). Early musical behaviors commonly arise spontaneously within social-emotional contexts (Kragness et al., 2023) with the development of musical aptitude appearing highly responsive to environmental experiences and the quality of musical instruction (Doxey & Wright, 1990). Moreover, especially in younger children, seemingly "ordinary" activities such as singing are often greatly underestimated in their impact on musical development (Papoušek, 1982; Trevarthen & Malloch, 2002). Thus, the home and social musical environment, and the musical stimulation provided play crucial roles in shaping musical development (Gembris, 2017). An ecologically valid approach to early musical development takes these factors into account,

acknowledging how childhood experiences and interests profoundly shape the development of talent, particularly in music (Gordon, 1979; Shuter-Dyson, 1985).

Encouraging children to engage playfully with music and to seek learning opportunities out of their own interest can help them develop their musical potential intrinsically. To support this, it is important to counteract an artificial divide into "musical" and "non-musical" children (Degé, 2025). A key factor is the musical self-concept—beliefs about one's musical identity and abilities—which has been shown to influence positively the engagement and attitudes toward music (Fiedler & Hasselhorn, 2020; Fiedler & Müllensiefen, 2015; Spychiger, 2007, 2013). Equally important is a growth mindset, i.e., the belief that skills can improve through effort (Dweck & Leggett, 1988; Dweck, 2000). A growth mindset enhances motivation and performance in music education (O´Neill, 2011; Eisinger et al., 2025) and can influence whether or not children seek access to musical learning (Sloboda et al., 1994). The fact that all 3 studies included in this work have encompassed *enthusiasm & motivation* as a facet of musicality further underscores its importance and relevance to ecological valid music research.

5.4 Limitations and future directions

In addition to the limitations discussed in the previous chapters, some broader limitations should be mentioned, as they may be relevant for future research. The ultimate goal of this research on conceptions and measurement of musicality was to lay the groundwork for studying musical development in ways that account for musical behaviors relevant in real-life settings and to encompass their complexity. While the studies presented here have explored conceptions of musicality in infants, toddlers, and children up to 6 years of age, future research could help clarify how conceptions of musicality evolve with age, particularly in children aged 6 to 10 years and adolescents, as these groups have not been studied. Moreover, the findings are primarily applicable to Western cultures, and future research should investigate how conceptions of musicality and its development differ across cultural contexts. Such investigations could also contribute to adapting measurement tools to ensure their intercultural relevance and validity. In addition, conceptions should be examined in terms of their stability and change over time.

Concerning the measurement of musicality, it is essential to develop valid and reliable tools in order to be able to address various questions, including interindividual differences in musicality, and how different aspects of musicality develop and interact (Forrester & Borthwick-Hunter, 2015). While the screening developed in Study 3 provides a valuable starting point, it enables only a brief overview of musicality. To gain a more thorough understanding, more comprehensive questionnaires should be developed. Furthermore, questionnaire-based measures capture adult perceptions of children's musicality, rather than directly assessing musical behaviors. Future research should,

therefore, complement these assessments with behavioral measures. Although perception tasks might be easier to administer (Okada & Slevc, 2021), tasks that explore more complex aspects such as *enthusiasm & motivation*, *musical communication* or *analytical understanding* might be more helpful in reflecting real life behaviors. To further stress ecological validity, these behavioral tasks could use authentic musical stimuli, require natural interactions with music, and be conducted in familiar environments such as the home. However, task performance may also be influenced by temporary factors such as current states and task engagement, which could limit the interpretability of scores from a single assessment of musical behavior (Okada & Slevc, 2021). To address this, systematic observational research could provide deeper insights into how various facets of musicality manifest in everyday contexts (Haroutounian, 2000; Swanwick 2003). In addition, subjective evaluations, incorporating blind testing and interrater reliability to ensure repeatable and rigorous results, may enhance ecological validity (Levitin, 2012). The combination of behavioral and observational methods could further be leveraged in longitudinal and intervention studies to examine how interindividual differences emerge and interact with environmental influences.

5.5 Conclusions

In summary, this dissertation takes an important first step toward achieving ecological validity in child musicality research. The studies explored conceptions of musicality in infants, toddlers and children and introduced a screening tool for its assessment. The findings contribute to the ongoing debate on the core facets of musicality and how they can be assessed in ways that capture the complexity of real-world musical behaviors. Emphasizing ecological validity, this dissertation highlights the need for more inclusive assessments that capture musicality as it naturally unfolds in everyday contexts. The development of the Child Musicality Screening represents an initial step towards this goal. Beyond these scientific contributions, the findings have practical implications. Consistently, all three studies identify *enthusiasm and motivation* as a key component of child musicality, thus challenging the traditional, narrower perspectives. Recognizing the role of enthusiasm and motivation in musical development provides valuable guidance for caregivers and educators. Caregivers should be encouraged to create a musically enriched environment and to reflect on their own beliefs about musical talent and its development, as they play a crucial role in fostering children's musical engagement. In music education, a key objective is to ensure all children have access to diverse musical experiences. This encourages them to engage with music in a way that is meaningful to them, ultimately supporting children to explore and realize their unique musical potential. The ultimate goal is to nurture the children's capacity to experience music as a lasting source of joy and inspiration throughout life. Moreover, these studies pave the way for a more inclusive approach to

music research—one that prioritizes ecological validity and acknowledges the richness of musical experience.

> *"Music science is now mature enough to take more risks in the scope of its investigations. If science is to demystify music and explain its power to affect us, it must investigate music as it is actually experienced." (Sloboda, 2008, p. 32)*

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II. PUBLICATIONS

7 Included publications

Study 1:

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2021a). What makes a child musical? Conceptions of musical ability in childhood. *Early Child Development and Care*, 191(12), 1985–2000. doi.org/10.1080/03004430.2020.1866566

Study 2:

Buren, V., Müllensiefen, D., Roeske, T.C., & Degé, F. (2021b). What makes babies musical? Conceptions of musicality in infants and toddlers. *Frontiers in Psychology,* 12:736833. doi.org/10.3389/fpsyg.2021.736833

Study 3:

Buren, V., Müllensiefen, D., & Degé, F. (2025). Screening musicality in children: Development and initial validation of a new tool for rapid assessment of musical profiles. *PLOS ONE*. doi.org/10.1371/journal.pone.031796

STUDY 1:

WHAT MAKES A CHILD MUSICAL? CONCEPTIONS OF MUSICAL ABILITY[3] IN CHILDHOOD

This is an article published by Taylor & Francis in Early Child Development and Care on February 19, 2021, available at: https://doi.org/10.1080/03004430.2020.1866566

[3] At this stage of my research, I used the term *musical ability* synonymously with *musicality*, as is common in the literature. Only after publication did I begin distinguishing between *musicality* as a broader construct and *musical ability* for more specific abilities.

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Verena Buren, Daniel Müllensiefen, Tina Roeske & Franziska Degé

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What makes a child musical? conceptions of musical ability in childhood

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ABSTRACT

Tests of musical ability in children have relied on diverse conceptions of what musical abilities are. Recent investigations suggest that such conceptions can be seen as socially constructed and differ between cultures, sub-groups, and individuals. Based on a previous study on conceptions of adult musical ability, we designed a questionnaire targeting musical behaviours of 3–6-year-old children. 922 German adults who regularly spend time with children assessed how often a musical child would show these behaviours. Principal component analysis revealed four components of childhood musical ability: musical communication, enthusiasm and motivation, analytical understanding of music, and musical abilities in a narrow sense. The importance assigned to the components differed depending on musical expertise: Participants with higher expertise rated analytical music skills as significantly less important. Results suggest that ecologically valid tests of musical ability in childhood should cover a wide range of skills and observable behaviours.

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Conceptions of musical ability; musicality; development of musical ability; children's musical skills; survey

Introduction

To investigate the development of musical abilities, various testing batteries and procedures have been devised and published over the course of the last century (e.g. Bentley, 1966; Gordon, 1965, 1989; Seashore, 1938/1967; Wing, 1981; the terms 'musical ability' and 'musicality' will be used interchangeably in the following). However, the available tests differ in their underlying conceptions of musicality (Shuter-Dyson, 1999). This has led to a great diversity of testing procedures that make it difficult to compare results across studies. To better understand how testing procedures relate to the manifold developmental processes that constitute musical development, it is useful to take a step back to review the concept of 'musical ability': Generally, musical ability is not assumed to be a natural and uniform trait, but a social construct with different meanings in different cultures, subgroups, and even individuals (Blacking, 1971; Hallam & Prince, 2003). It has been shown that everyday conceptions of adult musical ability are highly complex and comprise far more facets as normally included in test procedures (Hallam, 2010; Hallam & Prince, 2003). It has been suggested that common conceptions of *childhood* musicality are also broad and multiform (Haroutounian, 2000), but how accepted such broad conceptions really are has never been systematically investigated.

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In the present study, we examined the conceptions of childhood musicality as perceived by different groups of people with a wide range of expertise related to this topic (music teachers, teachers, parents and carers) in Germany. Our aim was to identify traits, skills, and behaviours that were considered as important indicators of musical ability in 3–6-year-old children, and to compare them to conceptions of musical ability in adulthood. To this end, we adapted previously collected statements on musical ability (Hallam & Prince, 2003) and made them applicable to young children. These statements formed part of a survey that was distributed to musicians and music educators, non-music educators, and parents and carers.

Developing a robust concept of musical ability is a prerequisite for investigating the processes underlying musical development, and for adequate use of test batteries and observational research tools to quantify musical development in children.

Assessing musical ability in childhood

Music is a cultural universal and all humans possess a potential for developing musical abilities and competence. Yet, there is strong disagreement on what constitutes the core set of musical abilities and how these are related to one another.

Seashore (1938/1967) was among the first to argue that musical ability is not a monolithic human feature but results from the interaction of various independent abilities, i.e. advocating a multifactorial model. This is reflected in the Seashore Measures of Musical Talent (Seashore, 1919) which consist of a collection of auditory discrimination tasks that are only slightly associated with each other (Seashore, 1938/1967) and result in a profile of musical ability.

In contrast, Bentley (1966) and others assumed that musical ability is a holistic and self-contained ability that may be described by a general factor model. The Measures of Musical Abilities published by Bentley (1966) include tasks on pitch discrimination, tonal memory, chord analysis, and rhythmic memory that all feed into one overall score. Note, however, that Bentley admitted that whether musical ability was more adequately described as a single ability or a collection of multiple abilities was a matter of empirical investigation (Bentley, 1966).

The lack of a uniform theoretical concept of musical ability is not only reflected by the different test procedures, but has also motivated extensive criticism of existing tests. Gordon's strong emphasis on audiation has sparked controversial debate (e.g. Colwell & Abrahams, 1991; Woodford, 1996) which resembles the general criticism that many musicality tests focus too much on aural perception (Hallam & Shaw, 2002). Moreover, this is also reflected by mixed results on psychometric test criteria, in particular, low validity of many tests (e.g. Demorest, 1995; Gembris, 1998/2013; Hallam & Shaw, 2002; Schleuter, 1993). The lack of clarity about the construct to be measured results in music tests that measure only those sub-competencies that the test authors considered fundamental (Gembris, 1998/2013; Shuter-Dyson, 1999). Researchers choose to measure musical ability 'in whatever way they see fit' and adapt their measurement procedure to suit their needs (Ollen, 2006, p. 1). Furthermore, critics have argued that the existing tests cannot capture the true nature of musicality and its development since they ignore a number of important abilities (e.g. musical communication, musical understanding, motivation; Murphy, 1999).

As a step forward, more recent studies (Hallam & Prince, 2003; Levitin, 2012; Murphy, 1999; Müllensiefen, Gingras, Musil, & Stewart, 2014) have proposed a more integrative concept of musical ability, in order to take into account the complexity of the phenomenon. This is meant to do justice to the broad repertoire of behaviours that can be described as musical (Levitin, 2012). Comprehensive concepts of musicality should not only cover the diverse skill sets of professional musicians (e.g. composing, arranging, conveying musical emotions, musical creativity), but also of amateur musicians or other music professionals (e.g. DJs, music critics; McPherson, 1995; Müllensiefen et al., 2014).

Taken together, applying a new perspective by *viewing musical ability as a social construct* could be a helpful step towards a better understanding of how test procedures, observable music-related

behaviours, and their development are related to each other. Assessing the conceptions of musical ability held by the general population, musicians, and music educators takes into account culture-specific features as well as social change. This allows to grasp the facets of the concept of musical ability in a way that reflects the actual experience of music.

Conceptions of musical ability

In a series of studies (Hallam, 2010; Hallam & Papageorgi, 2016; Hallam & Prince, 2003; Hallam & Shaw, 2002), Hallam and colleagues investigated conceptions of musical ability in the UK. Their starting point was a qualitative study of musical ability in adults. 415 individuals with varying musical backgrounds (musicians, non-musicians, young adults with and without musical involvement) completed the statement 'Musical ability is … ' in writing. Their written statements were then analysed in an iterative process of categorization. From this analysis emerged the following six super-ordinate themes and 21 sub-categories: (1) aural skills (e.g. having a musical ear), (2) receptive responses (e.g. listening to and/or understanding music, being actively responsive to music), (3) generative activities (e.g. being able to play or sing), (4) integration of a range of skills (no subcategories), (5) personal qualities (e.g. metacognition, motivation), (6) the question whether musical ability is innate or learned.

These complex categories reflect how differentiated the view of musicality is in the general population. While conceptions were dominated by active musical engagement (72% of the statements included a reference to singing or playing an instrument), participants also mentioned receptive abilities. Definitions became more complex the more actively involved in music participants were. Closest to conceptions of musicians were those of educators. However, educators placed greater emphasis on appreciation of music while musicians emphasized motivation, personal involvement and learning skills, metacognition, emotional expression and communication skills.

In a next step, these spontaneously self-generated statements were used to quantify how widespread the different notions of musicality were. 77 statements from the qualitative study (Hallam & Prince, 2003) were presented to 660 participants (musicians, educators, amateur musicians, children with and without musical engagement) who indicated their level of agreement to each statement. In this study, musical ability was most strongly associated with *having a sense of rhythm*, reflecting traditional conceptions relating to aural abilities. Further important categories were: *being able to understand and interpret music*, *express oneself through sound*, and *being able to communicate through sound*. Personal factors also seemed to be important: the *motivation to engage with music*, *personal commitment to music* and the *ability to musically engage with others* received the highest mean scores. A principal component analysis revealed six components of musical ability: (1) Playing an instrument or singing, (2) musical communication, (3) valuing, appreciating and responding to music, (4) composition, improvisation and related skills, (5) commitment, motivation, personal discipline and organization, (6) rhythmic ability, pitch and understanding. The generative skills (1) explained the highest proportion of variance, whereas aural skills (6) were rated as less important indicators of musical ability. Participants' musical background led to different points of emphasis: Musicians emphasized the importance of musical communication, while educators stressed the importance of creativity, and amateur musicians and non-musicians believed aural skill and motivation to be indicative of musical ability.

In sum, Hallam's studies have shown a rich and polymorphic view of musical ability in adults, containing typical facets like aural skills and less typical ones like motivation. This goes far beyond what is usually assessed in musical ability tests. However, assumptions and beliefs about *how* the different facets of musicality *develop and apply to young children* have not been empirically investigated yet. Are the same facets present in children, just to a lesser degree, or do children acquire some of these facets (e.g. motivation, responsiveness to music) earlier than others (e.g. performance skills)? Empirical research on the conceptions of musical ability in younger children is scarce. Instead, beliefs about musical ability in childhood are often approached in terms of retrospective studies on the

development of musical ability (Davidson, Howe, Moore, & Sloboda, 1996; Howe, Davidson, Moore, & Sloboda, 1995) or the identification of musical talent (Haroutounian, 2000).

Haroutounian (2000) explored *observable indicators* of musical talent, with the intent to provide a scientifically proven framework for identifying musically gifted children. Based on an analysis of talent descriptors found in nomination forms, rating scales, and checklists, the authors proposed three main categories of musical talent: (1) Musical ability and aptitude, (2) creative interpretation, and (3) commitment and self-discipline. In a quantitative survey, 244 music educators and other experts from the U.S. indicated which behavioural characteristics and performance descriptors of musical talent are observable, even in untrained musicians. Interestingly, scores for general behaviours such as sustained interest and self-discipline were higher than for musical skills in the strict sense. Among the latter, pitch and rhythmic accuracy had the highest mean score, followed by rhythmic performance, dynamics and technical fluency. Intriguingly, originality was rated as least important. In complementary expert interviews, the importance of perceptual awareness and discrimination, meta-perception, creative interpretation, performance, and motivation was stressed. As to the role of creativity, the results of the interview study contradicted those of the questionnaire. The experts in the interview study indicated creativity as an important component of musical talent, while the participants in the survey considered creativity to be of little use for identifying talent (Haroutounian, 2000).

Taking a different approach, O'Neill (2002) investigated conceptions of musical ability by evaluating *personal beliefs* about the construct. In an interview study, 172 children between 6 and 11 years of age from the U.K. were asked about their musical self-conceptions. These turned out to be based to a large extent on personal experiences with music: children who did not play an instrument showed a more rigid view of musical ability, assuming little opportunity for change. In contrast, musically experienced children had a more flexible view. Overall, ideas about musical ability were less flexible than ideas about athletic ability across all children (O'Neill, 2002).

In sum, several studies have provided empirical evidence that conceptions of (adult) musicality in the general population include a wide range of abilities. However, whether and how this range of abilities also applies to musical ability in childhood is still unclear.

In essence, there is a lack of systematic large-scale surveys on conceptions of musical abilities in childhood. Hence, our study aims at filling this gap by surveying people with extensive contact to children (musicians/music educators, non-music educators, parents and carers) about their views on musical ability in 3- to 6-year-old children. We based our online survey on the qualitative analysis of Hallam and Prince (2003), and compared our results with theirs on adult musicality (Hallam, 2010).

The results of our study may serve as a basis for the development of novel assessment batteries to measure musical ability in childhood that build on the conceptions of musicality as held by experts and the general population. This expanded perspective of musicality in young children can then serve as the scientific basis for future empirical research and a better understanding of musical development in childhood.

Method

Participants

Survey participants were adults who regularly spent time with children between 3 and 6 years. Participants (714 female) were between 18 and 75 years of age ($M = 41.98$, $SD = 9.36$). 46.2% had a university degree (among those, $n = 159$ had a degree related to music), 25.1% had the equivalent of A-levels, 24.5% had the equivalent of General Certificates of Secondary Education, and 4.2% had lower secondary school certificates or no degree. The sample comprised 167 music educators (18.1%), 180 early childhood educators (19.5%) and 551 participants (59.8%) with a profession not related to education. 24 participants (2.6%) did not state their profession.

Materials

Development of the musical child questionnaire

The new Musical Child Questionnaire (MCQ) was developed based on statements from Hallam's study on conceptions of (adult) musical abilities (Hallam & Prince, 2003). In that study, participants from different musical backgrounds completed the sentence 'Musical ability is … ' in written statements. We reformulated these statements to match the sentence 'A child who is musically skilled … ' (e.g. 'A child who is musically skilled has a good sense of timing and rhythm'). Statements were then translated into German and, where necessary, excluded or reworded to make them suitable for the target age group (3–6).

The translation was carried out in the following steps: One of the authors (German native speaker with near-native English skills) translated all items from English into German. The translation was subsequently validated by the three remaining authors (all German native speakers and highly fluent in English), and individual sentences were modified to make them sound more idiomatic wherever necessary (decisions were taken by majority vote between the authors). Next, items that appeared to be clearly unsuitable for the description of child musicality were excluded by consensus.

In other cases, the items could be adapted for the age group by rephrasing. Each author made suggestions for rewording of items. In a next step, the suggestions were validated by all authors together through discussion until unanimous consensus was reached.

As a final step, redundant items were eliminated. Decisions on dropping items due to redundancy were driven by the need to shorten Hallam's list of 134 items. 134 items would have resulted in an overly long online survey, especially for busy caregivers of small children. With the aim of shortening the list, the authors independently judged all items for redundancy (i.e. strong overlap in their key message), and again discussed and validated their suggestions together.

The focus of all items was on children's observable behaviours, and participants were asked to indicate how often a musical child would typically show such behaviours, responding on a 5-point Likert scale (1 = rare/never to 5 = always). The final version of the MCQ consisted of 49 items (see Table 1). All four subscales showed high reliabilities (all Cronbach´s $\alpha \geq .85$; for more details see Table 1)

Goldsmiths musical sophistication index

In order to assess the musical experience of the participants, we used the musical training subscale of the Goldsmiths Musical Sophistication Index which has been shown to have very good test-retest reliability and internal consistency and good validity (Müllensiefen et al., 2014). We used the musical training subscale from the German adaptation (Schaal, Bauer, & Müllensiefen, 2014) which consists of seven items on musical training and practice, as well as self-assessed musicianship. The scale showed high reliability (Cronbach´s $\alpha = .91$).

Demographic information

With the survey, participants also provided basic demographic information. These included age, gender, educational background, and profession.

Procedure

The data collection took place in Germany for 15 months in 2019 and 2020, mainly online. Participants were recruited through online channels (mailing lists of music schools, childcare institutions, and panel members of a market research company in Germany) and personal contact. As an incentive, six Amazon gift cards were raffled among the participants. Out of 1933 people who visited the survey homepage, 1074 participants actually started the survey (56%), 152 (14%) of which were excluded due to either incomplete responses (less than 50% of items answered), an implausibly

Table 1. Items of the Musical Child Questionnaire.

MCQ Item				Component Loading			
	A child between 3 and 6 years who is musically skilled …	*M*	*SD*	1	2	3	4
Component 1: Musical Communication (Cronbach´s α = .94)							
48	… can express him-/herself through sound.	3.22	1.01	.76			
28	… can express emotions that a listener understands when singing or making music.	3.25	.98	.74			
33	… brings several skills together: He/she has musical ideas and tries to implement them.	3.27	.93	.71			
26	… perceives the basic mood or feelings conveyed by the music that he/she is listening to.	3.37	.94	.67			
11	… is able to react to the mood of a melody.	3.55	.91	.66			
44	… would rather express themselves through music than through other means.	2.79	.98	.65			
49	… can listen carefully and react appropriately to music.	3.23	.91	.61			
34	… is able to produce or reproduce music.	3.35	.98	.61			
37	… listens while making music to see if it sounds as intended.	3.13	.98	.59			
17	… appreciates different kinds of music.	3.31	.96	.57			
40	… is motivated to make music, so that he/she becomes more and more skilled.	3.45	.92	.56			
27	… can communicate with others through music by producing musical sounds, listening, improvising, dancing, and understanding music.	3.46	.92	.55			
30	… can invent melodies or rhythms, either with his/her voice or a simple instrument.	3.51	.95	.52			
16	… has an open mind with which he/she approaches and experiences all music.	3.58	.89	.51	.30		
47	… can immerse him-/herself in sounds.	3.36	.97	.51			
25	… plays music with feeling.	3.67	.90	.50	.34		
10	… actively incorporates music into his/her world.	3.62	.89	.45	.38		
8	… shows that he/she can capture patterns when dancing or making music.	3.53	.88	.43			
13	… is able to react creatively, emotionally and intellectually when listening to a piece of music.	3.46	.93	.39			
5	… has a good memory for patterns	3.35	.87	.38			
12	… is able to move in synchrony with the music	3.61	.87	.38			
Component 2: Enthusiasm and Motivation (Cronbach´s α = .87)							
43	**… enjoys the occupation with music.**	**4.07**	.79		.80		
41	**… has great enthusiasm for music.**	**4.06**	.80		.75		
38	**… is interested in music.**	**4.01**	.82		.70		
14	**… enjoys music in his/her life, either by making music or by listening to it.**	**4.04**	.82		.67		
15	**… enjoys music and appreciates sounds.**	**3.93**	.82		.58		
39	… often has the desire to make music.	3.66	.88	.32	.56		
45	**… has a great affinity for music.**	**3.80**	.86		.55		.38
29	… is motivated to make music together with others, so that they become a group - be it by singing, playing instruments together, or moving to the music of others.	3.69	.94		.50		
32	**… is creative when making music.**	**3.72**	.87		.50		
31	**… likes to spontaneously produce music or musical sounds.**	**3.87**	.81	.35	.48		
46	A child is musical when music means something to him/her.	3.31	1.08		.33		
Component 3: Analytical Understanding (Cronbach´s α = .85)							
21	… applies criteria to evaluate music.	3.49	1.19			.89	
9	… can follow the structure of the music he/she listens to, and talk about it.	3.34	1.02			.77	
19	… is aware of different aspects of music, so you can talk to him/her about it.	3.19	.98			.64	
22	… is able to hear, compare and distinguish different types of music.	3.23	.98			.53	
20	… likes listening to music and can describe it with words and gestures.	3.55	.91			.49	
2	**… can reproduce melodies well.**	**3.75**	.90			.46	.41
18	… recognizes different types of music (e.g. children's songs, pop, classical music).	3.19	1.06			.38	
42	**… has a will of his/her own when making and enjoying music.**	**3.72**	.90		.31	.35	
36	… has a wide range of different skills.	3.44	.95		(.24)		
Component 4: Musical Abilities (Cronbach´s α = .85)							
6	… has a good sense of timing and rhythm.	3.50	.90				.77
7	… has a feeling for the beat.	3.50	.92				.70
1	… has a musical ear, i.e. he/she recognizes melodies and tone progressions.	3.67	.90				.69

(*Continued*)

Table 1. Continued.

	MCQ Item A child between 3 and 6 years who is musically skilled …	*M*	*SD*	Component Loading 1	2	3	4
35	… is able to combine hearing and sound production.	3.70	.85				.44
4	… has good hearing ability, e.g. for melodies and rhythms.	3.65	.86				.42
23	… can sing a simple melody or rhythm or play it with an instrument.	3.62	.90				.40
24	… has good overall physical coordination.	3.26	.89				.34
3	… is able to internalize sound, pitch and rhythm.	3.59	.89				.34

Note. *M* = Mean. *SD* = Standard Deviation. The ten items with highest mean values are displayed in bold. Only component loadings above .3 are shown, one item did not have any loadings above .3, therefore the highest loading which occurred is shown in brackets.

short completion time (<4 min for 68 Questions) or because of constant ratings. The resulting sample comprised 922 valid questionnaires.

This study received ethical approval from the Ethics Council of the Max Planck Society. Informed consent was obtained from all participants and the collection of e-mail addresses to participate in the raffle and/or to receive the study results was done in a separate survey which ensured that personal data could not be linked to the survey answers or demographic information.

Analytic strategy

Data were analysed using the R software environment (R Core Team, 2019), including the R packages psych (Revelle, 2020) and lavaan (Rosseel, 2012).

Our main goal was to find distinguishable facets of musical ability in children, and to explore how important these facets are relative to each other. Here, the aspects of adult musicality that Hallam (2010) based on qualitative content analysis (Hallam & Prince, 2003) were compared to the empirical grouping of items on the new MCQ. Different empirical groupings of the MCQ were obtained through principal component analysis (PCA) and their fit to the data was compared by confirmatory factor analysis. Averages of item groups were then compared.

In a next step, we explored if participants with a professional background in education or music education differ in their evaluation of musicality compared to parents and carers. To address this question, we transformed the existing MCQ into a short version through principal component analysis, which also makes it more suitable for future practical applications. Using the new scale, average component scores of music educators, general early years educators, and parents and carers were then compared with a multivariate analysis of variance.

Results

Descriptive analysis

In Table 1, mean ratings and standard deviations for all items are shown. The ten items with the highest mean ratings are displayed in bold. These ten items were thus rated by the participants as frequent indicators of high musicality in children between 3 and 6 years. Seven out of these ten highest rated items clearly relate to enthusiasm, interest and motivation which therefore seem to be important features of musicality in children.

Qualitative comparison to adult data

As a next step, we compared our results to those of Hallam (2010), who explored the conceptions of musical ability in adults in 660 individuals (aged 14–90). Their participants were predominantly female (67%) and had different levels of musical background (102 musicians, 95 educators, 132 adult amateur musicians, 60 adults who were not musically active, 193 children actively engaged

in making music and 71 children with no engagement with music outside school). In order to compare our results with the conception of musicality in adults, we grouped the items on the MCQ according to the categories used in the study by Hallam (2010), which did not report results at the item level. The classification employed by Hallam was based on an iterative procedure from an earlier qualitative content analysis (Hallam & Prince, 2003). Only 18 out of the 21 original categories describing adult musicality were used. Items on 'reading music' and 'expressing thoughts and feelings through sound' did not have any correspondences in the MCQ because there were deemed as redundant or not applicable for the target age group of the MCQ. Questions regarding the 'Origins of Musicality' were also not part of our survey.

Mean ratings of musicality categories showed only a weak and non-significant correlation (Pearson $r = .12$, $p = .64$, Spearman $r_s = .08$, $p = .76$). This suggests that the conceptions of children's and adults' musicality differ considerably.

Figure 1 shows the 18 categories with average ratings for children (MCQ) and adults (Hallam, 2010) side-by-side. Again, *motivation, creativity* and *appreciation of music* appeared as most important in children, followed by *composing and improvising*, and *group performance*. Rated as least important for children were *knowledge about music*, *technical skills*, and *meta-cognition*. Bonferroni-corrected *t*-tests at the category level show that the mean responses in almost all categories differ significantly between adults' and children's musicality (Figure 1) with the exception of *integration of skills* and *personal characteristics*.

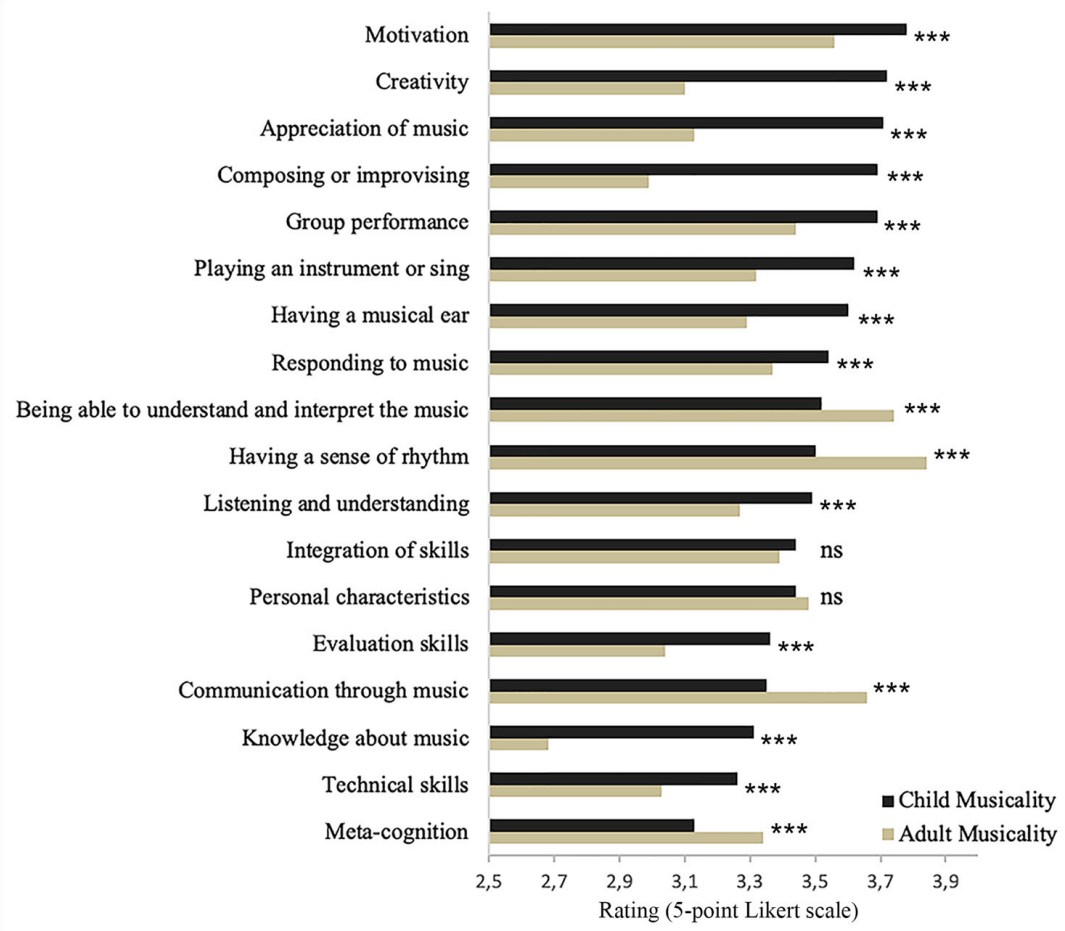

Figure 1. Comparison of Category Means for child and adult musicality. Ratings for children in black, ratings for adults (from Hallam, 2010) in tan. All *p*-values are results of two-tailed t-tests. *** $p < .001$. ns = not significant.

Only four categories were perceived as being more important for musicality in adults than in children: *having a sense of rhythm*, *communication through music*, *being able to understand and interpret the music*, and *metacognition*. All other categories were rated as significantly more important for child musicality. Here, the categories with the greatest difference in mean values were *composing and improvising*, *knowledge about music*, *creativity* and *appreciation*.

Grouping items of the MCQ

Three PCA models were computed to group the items of the MCQ into distinct components. We designed the first PCA model to replicate the model of Hallam (2010), using the same number of components ($k = 6$) and rotation (varimax rotation). This model explained 55% of variance among the 49 items (see Table 2 for root mean square of the residuals). The second PCA model used the same criterion for deciding the number of components that Hallam (2010) had used (i.e. select all components with eigenvalues > 2) while also using varimax rotation (as Hallam, 2010). The resulting 3-component-solution explained 46% of the item variance. The third PCA model was carried out independently of Hallam's prior calculations to achieve an optimal model-data-fit. We used parallel analysis (Horn, 1965) to determine the number of PCA components by comparing the empirical eigenvalues to the eigenvalues determined by simulation and resampling from the same dataset. A 4-component solution was suggested as optimal. This time, oblique rotation was applied to the resulting model, because we assumed from theoretical considerations that the components would be related, following McDonald's (1999) argument that facets or dimensions of the same construct are likely to be related rather than completely independent of each other (McDonald, 1999). The resulting 4-component solution explained 50% of the item variance.

For comparing the model-data fit of the PCA models, we conducted confirmatory factor analyses of all three models. Fit indices are given in Table 2 and show that the 4-component PCA model based on parallel analysis had the best fit to the data according to the Bayesian Information Criterion (BIC), while relative (TLI, CFI) as well as absolute fit indices (RMSEA, SRMR) for the 4-component PCA were also in an acceptable to good range (see Table 1 for items and their loadings).

Component 1 was interpreted as *musical communication*. It comprised 21 items with component loadings from .38 to .77 and included items that described a spontaneous, emotional approach to music both when listening and when expressing oneself. The second component, *enthusiasm and motivation*, comprised 11 items indicating the enthusiasm, the affinity and the enjoyment of music and the motivation to make music. Component loadings ranged from .33 to .80. Component 3, *analytical understanding*, focused on the analytical understanding of music (e.g. 'A musical child is aware of different aspects of music, so that it is possible to talk about them'), and the use of knowledge to evaluate music (e.g. 'A musical child applies criteria to evaluate music'). Component 3 included 8 items with component loadings from .35 to .90. Component 4 was termed *musical abilities*. It was composed of 8 items on basic musical abilities concerned with audiation, musical parameters such as pitch, melody, pulse, timing, and rhythm, and the integration of these abilities for making music. Component loadings ranged from .36 to .76. Table 3 shows the mean ratings and the amount of explained variance by component.

Table 2. Fit indices of computed models.

	BIC	TLI	CFI	RMSEA	SRMR
6-component PCA	99212.03	.850	.858	.056	.057
3-component PCA	99931.18	.815	.823	.062	.057
4-component PCA	97207.80	.839	.847	.059	.059

Note. BIC = Bayesian Information Criterion. TLI = robust Tucker-Lewis Index. CFI = robust comparative fit index. RMSEA = robust root mean square error of approximation. SRMR = standardized root square residual.

Table 3. Mean ratings grouped by components.

	Means	*SD*	*n*	Explained variance
Musical Communication	3.38	.64	922	20%
Enthusiasm and Motivation	3.86	.58	922	12%
Analytical Understanding	3.43	.70	922	9%
Musical Abilities	3.55	.62	922	9%

Note. SD = Standard Deviation. *n* = number of participants.

Professional background and expertise associated with differences in the evaluation of children's musicality

The grouping of items on the MCQ provides an informative classification suggesting four different facets of children's musicality. However, for investigating how ratings differ between participants (e.g. due to professional background or musical expertise) the full MCQ represents neither a practical nor robust measurement instrument. Responding to 49 items is too time consuming for most research studies that may also include additional questionnaires. In addition, many items showed relatively low component loadings which can produce skewed results when unit weighting is used for scoring. Hence, a scale was constructed using the polychoric correlation matrix of the 49 items as input to parallel analysis. Four components were identified as optimal and oblimin rotation was applied to allow correlations between components. Only items with component loadings of >.6 were retained. This yielded a 4-component solution comprising 15 items (the retained items and their respective loadings are shown in Table 4) that was highly similar to the PCA model comprising all 49 items. Therefore, the same labels were used for naming the four components (1 musical communication, 2 enthusiasm and motivation, 3 analytical understanding of music, 4 musical abilities).

Component scores were computed for all participants using regression and subsequently comparted with a multivariate analysis of variance with professional background (musicians/music educators, non-music educators, parents and carers) as the independent variable and the four component scores as dependent variables. Using Pillaís trace, we found a significant effect of professional group on the components of our measurement instrument $V = 0.27$, $F(8,1732) = 33.76$, $p < .001$. Separate univariate ANOVAs on the scores of the four components revealed a significant difference only on component three (analytical understanding of music), Welch´s $F(2,302) = 123.99$, $p < .001$ in a linear relationship ($F(1,868) = 208.90$, $p < .001$; see Figure 2).

Table 4. Items of the short scale of the Musical Child Questionnaire with component loadings.

	MCQ Item	Component Loading			
	A child between 3 and 6 years who is musically skilled …	1	2	3	4
Component 1: Musical Communication (Cronbach´s α = .85)					
48	… can express him-/herself through sound.	**.86**	.03	-.04	.03
28	… can express emotions that a listener understands when singing or making music.	**.85**	.03	.04	-.05
33	… brings several skills together: He/she has musical ideas and tries to implement them.	**.77**	.11	.01	.07
49	… can listen carefully and react appropriately to music.	**.66**	-.04	.11	.21
Component 2: Enthusiasm and Motivation (Cronbach´s α = .82)					
43	… enjoys the occupation with music.	.04	**.90**	-.04	-.05
38	… is interested in music.	.12	**.85**	.03	-.11
41	… has great enthusiasm for music.	.00	**.81**	.02	.09
14	… enjoys music in his/her life, either by making music or by listening to it.	-.16	**.67**	.08	.30
Component 3: Analytical Understanding (Cronbach´s α = .81)					
21	… applies criteria to evaluate music.	-.12	.05	**.95**	-.07
9	… can follow the structure of the music he/she listens to, and talk about it.	.08	-.04	**.83**	.07
19	… is aware of different aspects of music, so you can talk to him/her about it.	.19	.02	**.63**	.15
22	… is able to hear, compare and distinguish different types of music.	.38	.00	**.54**	.01
Component 4: Musical Abilities (Cronbach´s α = .80)					
6	… has a good sense of timing and rhythm.	.03	-.02	-.03	**.90**
7	… has a feeling for the beat.	.14	.00	-.04	**.80**
1	… has a musical ear, i.e. he/she recognizes melodies and tone progressions.	-.05	.09	.13	**.77**

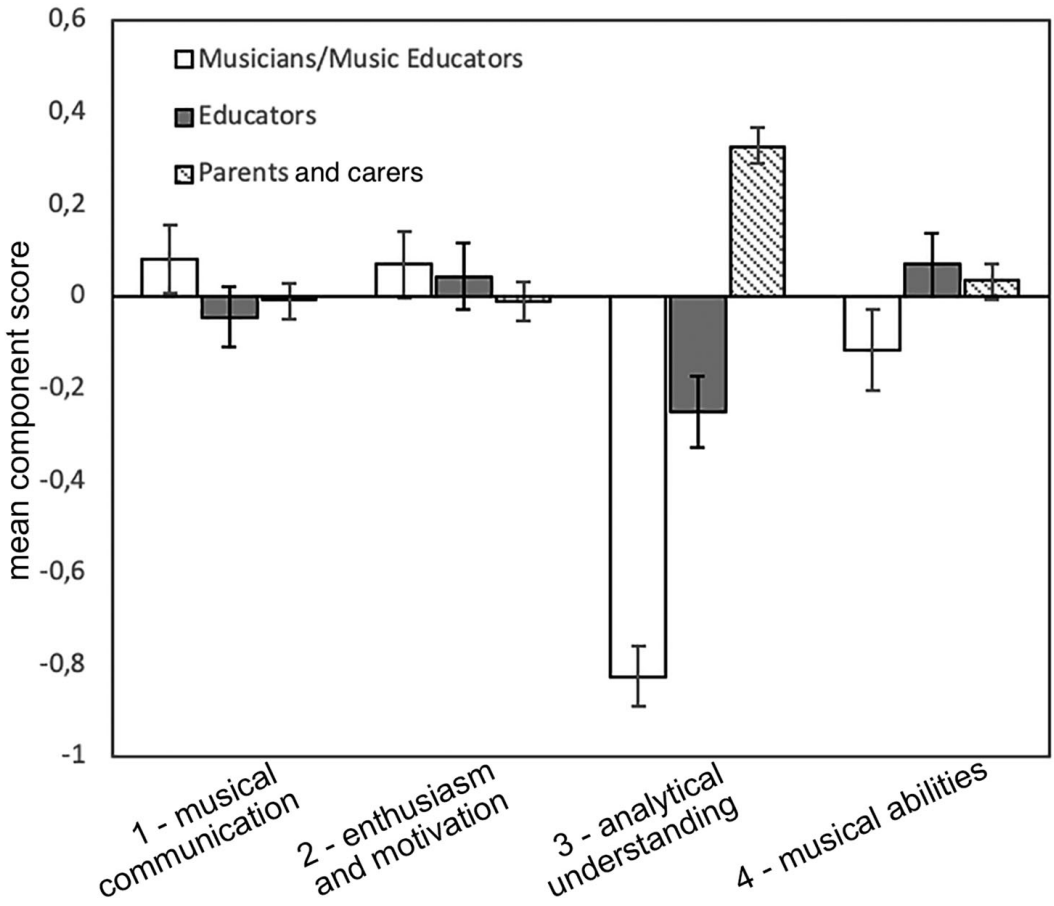

Figure 2. Mean component scores by professional groups. Error bars: standard error of the mean.

Games-Howell post hoc analysis indicated significant differences between all three groups (all p values < .001) with musicians/music educators perceiving analytical understanding of music as less important than educators without any special music background. In turn, educators perceived analytical understanding as less important than parents and carers.

The negative relationship between musical expertise and the evaluation of analytical music skills was also replicated by correlating the Gold-MSI musical training scores with the four component scores of the musical child scale. The correlation between the amount of musical training that an individual has received over their lifetime and the evaluation of *analytical understanding of music* in children is significant and weakly negative ($r = -.30$, $p < .001$). The correlations between musical training and *musical communication* ($r = .12$, $p < .001$) and *enthusiasm and motivation* ($r = .10$, $p < .01$) are weakly positive, and the correlation between musical training and the component *musical abilities* was non-significant ($r = .06$, $p = .07$).

Discussion

This study examined the conceptions of childhood musical ability held by German adults. Our adult participants, who had varying degrees of experience with children, music, and education, held differentiated conceptions of musical ability that also included traits, behaviours, and abilities not typically captured by common musicality tests. We identified four components of children's musical ability: *musical communication*, *enthusiasm and motivation*, *analytical understanding of music*, and *musical abilities*. Although '*musical abilities*', that are traditionally assessed by psychometric tests *are*

represented by one component, the component *enthusiasm and motivation* was considered as even more important by the survey participants. The role of *analytical understanding* was less clear. Musicians and music teachers described this component as *less* important than educators, while parents and carers attributed the greatest importance to this facet. *Musical communication* received the lowest ratings.

Our results show that motivational factors were considered to be a particularly important key component of childhood musicality. This reflects the respondents' awareness that exercise and stamina are necessary to develop musical ability. Enthusiasm for music and the motivation to engage with it are likely assumed to support this process. This is consistent with earlier findings that have shown that motivation is part of adult musical ability (Hallam, 2010; Hallam & Prince, 2003). In addition, experts suggested that motivational aspects should be taken into account in the search for musical talent in children (Haroutounian, 2000). The enjoyment of music, as well as the intrinsic motivation that develops through pleasurable experiences with music, have often been described as an important precursor to musical engagement and as a prerequisite for the inevitably strenuous practice necessary to develop musical skills (Sloboda, Davidson, & Howe, 1994).

Our data suggests that motivation should be part of comprehensive music test batteries for children. However, measuring this component poses challenges: It cannot be tested simply like a particular skill, and questionnaires would have to be filled in by parents or teachers. Another possibility to capture musical motivation are systematic observations of musical behaviour of children (Haroutounian, 2000; Swanwick, 1988). Despite the criticism that motivation can be short-lived (Karma, 2007), the assessment of motivation and enthusiasm for music could help clarify its role in musical development processes.

Another important indicator of musical ability in childhood was *musical abilities* in the narrower sense: audiation ability, a feeling for beat, timing and rhythm, and the ability to recognize and internalize pitch and melodies. The component also included basic music production skills (e.g. 'A musical child can repeat a simple melody or rhythm by singing or playing an instrument'), which emphasizes the importance of including music production in the assessment of musical ability. Traditional test batteries (e.g. batteries by Gordon, Seashore, Bentley) cover many of these skills, but tests that require children to produce music actively need to complement traditional batteries (e.g. music screening for children; Jungbluth & Hafen, 2005).

Analytical understanding of music emerged as another component of children's musical ability in our survey. This component describes cognitive aspects of musical ability: an understanding of musical elements that enables the child to recognize and analyse, describe, compare, and evaluate music. In a previous, qualitative study on everyday conceptions of musical understanding in adults, the largest percentage of spontaneously generated descriptors also referred to the understanding of musical elements (Hallam & Papageorgi, 2016). Thus, the awareness and conscious processing of musical elements is perceived as a crucial element of musical ability in adults.

The component of *musical communication*, in contrast, had a focus on emotional aspects of music. It included the emotional perception of music as well as expressive and creative ability and an openness towards all music styles. Perceptive and expressive abilities seem to be tightly linked: Sloboda et al. (1994) have argued that building structure-emotional connections through emotional experience of music is a necessary precursor to spontaneous expressive performance.

This study also compared conceptions of childhood musicality between groups of people involved in music to different degrees, because previous studies have shown considerable differences between groups of participants (Hallam, 2010; Hallam & Papageorgi, 2016; Hallam & Prince, 2003; Hallam & Shaw, 2002). In our study, only ratings on one component (*analytical understanding*) differed significantly between professional groups. Interestingly, musicians and music teachers perceived musical understanding as being *less* important than educators without musical background, who, in turn, rated it still lower than parents and carers. This could either indicate that musicians generally consider these skills to be less essential for musical ability, or that they believe that this skill is fundamentally learnable and therefore not yet as relevant at the age of 3–6.

When comparing our results with the conceptions of musical ability in adults (data from Hallam, 2010), the ratings of the participants differed significantly across most categories. In conceptions of musical ability in childhood, motivation, creativity, and appreciation of music received the highest ratings, which could indicate that these are seen as important prerequisites to develop musical potential, while in adults, musical ability was strongly associated with productive and aural skills (Hallam, 2010).

Although our results differed markedly from those of Hallam (2010), some similarities existed. In general, Hallam showed that conceptions of musical ability in adults are more complex than definitions used by musicality tests. This seems equally true with the conceptions of children's musicality. At the level of components, *musical communication* appeared in both models, whereas our component *enthusiasm and motivation* can be attributed to the two components of adult musicality *valuing, appreciating and responding to music*, and *commitment, motivation, personal discipline and organization*. The components of child musicality *analytical understanding of music* and *musical abilities* correspond to Hallam's component *rhythmic ability, pitch and understanding*. Those components which are not found in our model primarily describe abilities that are naturally less pronounced in early childhood (*playing an instrument or singing* and *composition, improvisation and related skills*).

When comparing our results with Haroutounian's study on musical ability in children (Haroutounian, 2000), there is strong overlap between the two models. A broad consensus among the experts showed that sustained interest and motivation were seen as very important components of musical ability, which is consistent with our results. However, Haroutounian's model does not include an equivalent to our component *analytical understanding*, which is a further indication that music experts attach less importance to this facet of musicality in childhood.

Practical implications

The insights gained in this study provide some practical implications for music education. Our results suggest that modern early musical education should promote a wide range of different skills that contribute to the musical development of children. The development of musical potential goes beyond practicing a musical instrument, as there is a rather wide range of possible ways to experience music. These can be provided by creating a diverse, musically enriched environment and taking individual interests into account. We suggest, based on our results, that the promotion of interest in music, inspiration and creative experimentation with music is one of the most important goals of pre-school educational processes. Especially in childhood, the development of musical abilities heavily relies on motivational factors and early experiences. A social environment in which music is appreciated and enjoyed is critical for the future development of musical abilities (Shuter-Dyson, 1999). The role of preschool music teachers should focus on enabling children to experience music as fun, inspiring and fulfilling. In addition, educators should be aware that assumptions that children make about their own musicality or lack of musicality can be crucial in determining how individuals feel about musical engagement, and whether or not they seek access to music learning (Sloboda et al., 1994).

Limitations and future directions

While our findings are in line with previous research on the topic, there are some limitations due to the design of our investigation. We based our questionnaire on qualitative statements collected in an earlier study on adult musicality which was conducted in the United Kingdom (Hallam & Prince, 2003). This approach ensured that statements were not based on our own perception of musicality but on conceptions in a greater sample of different groups of people. Although we have carefully adapted these statements to make them suitable for musicality in childhood, future studies could investigate whether qualitative surveys with open-ended questions would raise additional points. A related possible source of bias could be due to cultural differences between Germany and the

UK (where the original survey was conducted). However, comparable high mean ratings suggest that this did not greatly affect our results.

Another possible source of bias is the composition of the sample in this study. Our sample cannot be considered representative of the general population, nor the population of educators, music educators or musicians. Instead, the sample consisted of self-selected and mostly highly educated and predominantly female participants who regularly spend time with children in the relevant age group. Since the majority of participants were female, our results primarily reflect the conceptions of musicality from a female perspective. This was similar in previous studies (Hallam, 2010; Hallam & Prince, 2003). Therefore, the role of gender and educational level should be investigated in more detail in further studies. Possibly, a greater variation in sample would lead to even more diverse conceptions.

Because our study was explorative in nature, several interesting starting points for future research can be derived from it. Our results confirm the notion that musical ability in childhood comprises a range of broader abilities and explicitly takes into account motivational factors and musical communication. This broad conception is not yet reflected in current scientific measurement instruments. Therefore, our results could be used to identify gaps in current testing procedures and form the basis for extending these to better reflect current conceptions of musicality. One example of a measurement instrument which takes into account the multifaceted nature of musicality is the Goldsmiths Musical Sophistication Index (Gold-MSI, Müllensiefen et al., 2014) which can be used to assess self-reported musical skills and behaviours in adults. In the long run, a valid assessment of this broader conception *of children's musicality* could lead to a more comprehensive picture of children's musical development processes. This broader conception may also take into account that every child has a musical potential that can be developed and that there are many ways to benefit from musical engagement, even outside of a professional career as a musician.

Conclusion

In conclusion, our data suggest that besides those musical abilities commonly assessed by standardized measurement instruments, three other facets of musicality are perceived to be important in a musical child: enthusiasm and motivation, analytical understanding of music, and musical communication. Testing tools should thus aim to assess a broader range of abilities and features. Developing a test battery that includes measures of these facets is challenging but holds the promise to enrich a wide range of future empirical approaches to better understand musical development in early childhood.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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STUDY 2:

WHAT MAKES BABIES MUSICAL? CONCEPTIONS OF MUSICALITY IN INFANTS AND TODDLERS

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What Makes Babies Musical? Conceptions of Musicality in Infants and Toddlers

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Despite major advances in research on musical ability in infants, relatively little attention has been paid to individual differences in general musicality in infants. A fundamental problem has been the lack of a clear definition of what constitutes "general musicality" or "musical ability" in infants and toddlers, resulting in a wide range of test procedures that rely on different models of musicality. However, musicality can be seen as a social construct that can take on different meanings across cultures, sub-groups, and individuals, and may be subject to change over time. Therefore, one way to get a clearer picture of infant musicality is to assess conceptions of musicality in the general population. Using this approach, we surveyed 174 German adults, asking about their view and conceptions regarding behaviors that characterize a musical child under 3 years. Based on previous studies on adult and child musicality, we designed a survey containing 41 statements describing musical behaviors in children. Participants were asked to rate how indicative these behaviors were of musicality in infants and toddlers. PCA analysis revealed 4 components of musical abilities and behaviors in under-3-year-olds: Musical Communication, Enthusiasm and Motivation, Adaptive Expressiveness, and Musical Abilities as traditionally defined. Professional background and musical expertise of the respondents did not significantly influence participants' conceptions. Our results suggest that, in order to capture musicality in young children, a wider range of skills and observable behaviors should be taken into account than those assessed by traditional musical ability tests for young children.

Keywords: musicality, musical ability, conceptions of musical ability, development of musical ability, survey, infants, toddlers, musical development

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INTRODUCTION

Across the last century, a wide range of tests have been developed to measure musical ability in childhood (e.g., Gordon, 1965, 1979, 1982, 1989a,b; Bentley, 1966; Seashore, 1967; Wing, 1981). Strikingly, these instruments are based on a very diverse range of different theoretical models and conceptions of musical ability (Shuter-Dyson, 1999). This diversity is due to the fact that musicality is not a natural category, but a social construct that can take on different meanings in different cultures, subgroups, and even individuals (Blacking, 1971; Hallam and Prince, 2003). We here use the term musicality to describe a broader understanding of musical ability that includes not only musical perception and production, but also emotional responses to music, emotional

expressiveness through music, and interest and motivation in musical activities. In contrast to the term musicality, the term musical ability is often associated with musical perception or production skills assessed by traditional behavioral tests. The social construct of musicality cannot be assessed directly because it can manifest itself through a wide range of observable behaviors with relation to music. Therefore, it is necessary to identify indicators that reliably reflect the construct. The identification of behavioral indicators of musicality can lead to a broader understanding of how (conceptions of) musicality change(s) across different target ages and serve as a starting point for the development of age-appropriate test procedures, which can then be used to determine early musical skills and to map individual developmental trajectories.

In order to investigate musical development from the very beginning, it is essential to capture the first signs of musicality. Early observations by parents and educators can provide important information about which behaviors are perceived as the first indicators of musicality. Therefore, the objective of the present study was to investigate conceptions of infant/toddler musicality as perceived by adults in Germany with different professional backgrounds and musical expertise. The aim was to determine which abilities and behaviors in infants and toddlers are interpreted as indicators of musicality. This knowledge will enable us to deepen our understanding of what constitutes musicality in the first years and to develop a clearer picture of early musicality and its facets. The results of this study may help to explain how musicality can be described in infants and toddlers and thus provide a basis for developing appropriate measurement procedures in the future.

The Development of Musical Abilities

Music is a cultural universal (Merriam, 1964; Blacking, 1995) and all humans are assumed to possess a potential for musical competence (Trehub et al., 2015a). Current research suggests that the development of musicality begins in the womb and continues into adulthood (Gooding and Standley, 2011) through processes of enculturation and musical training (Hannon and Trainor, 2007).

Musical Development in the First Years of Life

Already in the first months of life, children can develop amazing perceptual abilities (Trehub, 2003). For example, sensitivity to melodic contours and relative pitches are developed in early infancy (Trehub, 2015). Moreover, certain perceptual abilities that are central to music cognition are initially universal, i.e., infants have the perceptual prerequisites to recognize the musical subtleties of any musical culture (Trehub, 2015). However, over time, culture-specific attunement takes place, and children develop more and more culture-specific skills (Trehub, 2015). An example is rhythm perception, where 6-month-old infants show a culture-general pattern of responding to musical rhythms, whereas 12-month-old infants already show an adult-like, culture-specific pattern of responding (Hannon and Trehub, 2005).

Rhythm production skills also develop rapidly in early childhood. Although two-and-a-half-year-olds can already adapt the tempo of their drumming to that of a drumming partner (Kirschner and Tomasello, 2009), synchronous drumming with a rhythmic pattern is not achieved until around the age of 4 (Provasi and Bobin-Bègue, 2003). Other skills (such as sensitivity to harmony) do not develop until later childhood (e.g., Schellenberg et al., 2005).

Infants are also generally attracted to music and music-like stimuli (like infant-directed speech) from a very early age and give carefully matched expressive responses. By doing this, they create co-operative patterns of communication that can be interpreted as a form of communicative musicality (Malloch, 2000; Flohr and Trevarthen, 2008), in which early singing-like and speaking-like vocalizations are still indistinguishable (Stadler Elmer, 2012). After their first birthday, children are increasingly able to express themselves musically: they dance to music in a rudimentary way (Trehub, 2015), and a few months later, their early vocalizations differentiate into speaking and singing, with early singing showing characteristic features such as glissandi, unstable pitches, singing with indefinable sounds, neologisms, short phrases in a narrow vocal range, and small and imprecisely tuned intervals (Stadler Elmer, 2012). Thus, while rudimentary singing is already present in under 3-year-olds, children become more sophisticated between the ages of 3 and 4 and begin to combine songs or song fragments. They hereby increasingly succeed in approximating the phrase contours of a song (Gembris, 2017), until the development of singing ability is largely complete in 8-year-olds (Davidson, 1994).

The Musical Environment of Babies

Especially in early childhood, parents and their musical practices in the home environment have a major influence on children's musical lives (Ilari, 2018). One of the first and most common musical interactions with babies is singing (Ilari, 2005; Young, 2008). When singing to their infants, parents sing in a distinctive manner [e.g., by using high pitch, slow tempo, and more expressive rendering of lyrics (Trehub et al., 1997a,b)]. This so-called infant-directed singing is often used to modulate infant arousal (Shenfield et al., 2003; Trehub et al., 2015b) and it also serves social bonding functions (Trehub, 2015). Especially in musical interactions with babies, singing is an important way of musical interaction with the caregiver (Ilari, 2005; Costa-Giomi and Ilari, 2014). Additionally, the special importance of the voice has also been demonstrated in a series of studies which have shown that sung melodies are better remembered than instrumental melodies (Weiss et al., 2012, 2015, 2021). Besides singing, many parents rely on recorded music or modern toys with musical features to create a musical environment for their children (de Vries, 2009; Mehr, 2014). Although the use of recorded music offers many advantages (e.g., the ability to engage with music without a parent, the ability to offer a greater variability of styles), recorded music lacks the multimodality of live interaction with a caregiver. In addition, there seems to be a widespread belief that educational settings provide children with a more comprehensive musical experience (de Vries, 2009) which may lead parents to think that their own musical interactions are of lesser importance. This suggests that parents' goals and beliefs about their children's musical development are very influential,

as they affect the styles and practices they use with their children (McPherson, 2009). Therefore, it is important to define musical development not only from current theories of human development, but also to consider musicality as a social construct that is influenced by contemporary discourses in music education research, by different approaches in educational practice, and by common believes about child musicality as held by parents, carers, and educators.

Assessing Musicality in Childhood

There are already many findings on "age-related stages of mastery of basic elements of the Western-European music system" (Stadler Elmer, 2011, p. 13). Thus, many studies examine skills that are present on average at a given age in order to draw conclusions about common developmental trajectories (Stadler Elmer, 2011). However, this can lead to glossing over or omitting important dimensions/indices of musical development (Forrester and Borthwick-Hunter, 2015). Although this approach may show that a skill or competence has emerged, it can easily fail to capture the causes, context and important associations of its emergence (Forrester and Borthwick-Hunter, 2015). A more comprehensive approach requires the consideration of more complex behaviors in culturally embedded settings (as has been shown for early singing development; see Stadler Elmer, 2011, 2012). The extension and integration of the existing findings and the implementation of a test battery based on these findings to monitor musical developmental processes could be a long-term goal of research on musical development.

While developmental science has made great progress in assessing how and when different basic musical abilities develop (see Trehub and Hannon, 2006; Trainor and Unrau, 2011; Trehub, 2015, for comprehensive reviews on this topic), relatively little progress has been made toward understanding how these abilities relate to each other and to the conception of general musicality. To study the development of general musicality adequately, we need scientific measurement tools that have a solid basis in developmental theory as well as being compatible with the conceptions of musicality of important stakeholders (i.e., general and music educators, carers, parents).

One approach to the study of musical ability is the use of standardized tests. However, these cannot be used with children under 3 years of age. Additionally, the traditional tests used in later childhood [such as the Seashore Measures of Musical Talent (Seashore, 1919), the Measures of Musical Abilities developed by Bentley (1966), or the "Gordon tests" (Gordon, 1965, 1979, 1982, 1989a,b)] place an emphasis on auditory and receptive skills and largely neglect music production behavior (composing, improvising, playing an instrument, or singing), motivation, and emotional and communicative elements (such as aesthetic responses, musical communication, and expressiveness). Thus, these measures are unlikely to be sufficient to provide a comprehensive picture of musicality and its development (Murphy, 1999). In addition, before assessing a construct, it is useful to clearly define which components are to be assessed in the first place (which requires a clear definition of musicality and its different facets). Some researchers have even questioned whether a single test of musical ability can capture the manifold manifestations of musicality at all (Murphy, 1999), which is especially true for infants and young children. Therefore, measurement instruments need to be highly adapted or supplemented with age-appropriate observational instruments based on a clear definition of musicality.

Parent reports can therefore be a valuable source for the study of musical behaviors in young children. An example is the Children's Musical Behavior Questionnaire (Valerio et al., 2012), which surveys music-related behaviors (as documented by parents about children and themselves). It includes 97 items aimed at finding out how often children exhibit a range of musical behaviors (e.g., singing, dancing, or listening to music). Seven factors relate to child-initiated musical behaviors (Attention and Emotion, Vocalizations, Moving, Daily Routines, Requests, Taking Turns, Creativity) and one relates to parent-initiated activities.

An even more comprehensive survey is the Music@home questionnaire (Politimou et al., 2018) which was designed to systematically map musical engagement in the home environment of young children. The infant version (3–23 months) of the Music@Home scale examines four factors: Parental beliefs (i.e., what parents think about music and development), Child engagement with music, Parent initiation of singing, and Parent initiation of music-making. In the Preschool version (2–5.5 years) the four factors were Parental beliefs, Child engagement with music, Parent initiation of singing, and Breadth of musical exposure.

Questionnaires such as the Children's Musical Behavior Questionnaire and the Music@home questionnaire are valuable for identifying musical opportunities and behaviors in infants and young children. They enable the empirical documentation of musical behaviors that children exhibit in their home environment and how parents use their musical nurturing opportunities. In addition, they take advantage of primary caregivers' rich knowledge about their children's development, which cannot always be adequately accounted for in laboratory studies. However, they do not extensively elucidate what *conceptions* of musicality underlie the behaviors exhibited. Moreover, interindividual differences and comparisons across different trajectories of musical development are much less a focus of these questionnaire and survey instruments.

Conceptions of Musicality

Approaching musicality as a social construct, Hallam and colleagues examined how people with different musical experiences conceptualize musicality (Hallam and Shaw, 2002; Hallam and Prince, 2003; Hallam, 2010; Hallam and Papageorgi, 2016). In a first qualitative study, Hallam and Prince (2003) asked 415 participants (adults and adolescents) from the United Kingdom to complete in writing the statement "musical ability is...". In an iterative process of categorization, the collected statements were analyzed and six overarching themes were identified (aural abilities, receptive responses, generative activities, integration of a range of abilities, personal characteristics, whether musical abilities are innate or learned).

Overall, the statements contained more references to active music making than to receptive skills and became more complex as respondents' musical experience increased.

The 77 statements derived from the qualitative study then served as a starting point for the quantitative study of musical conceptions (Hallam, 2010). Six hundred and sixty participants (musicians, educators, amateur musicians, children with and without musical engagement) rated these statements according to their level of agreement. Through principal component analysis, the authors identified six components of musicality: (1) playing an instrument or singing, (2) musical communication (communicating emotions through music), (3) valuing, appreciating, and responding to music, (4) composition, improvisation, and related skills, (5) commitment, motivation, personal discipline and organization, (6) rhythmic ability, pitch, and understanding. The conceptions differed between participants depending on their professional and musical experiences: Musical communication was perceived as the most important ability by musicians, whereas educators placed more emphasis on creativity. In contrast, amateur musicians and non-musicians held the belief that musicality is constituted by high aural skills and motivation.

In order to investigate whether these conceptions of musicality in general also apply to conceptions of musicality in childhood, the statements of the original study by Hallam and Prince (2003) were adapted so that they corresponded in principle to the abilities of the relevant age group (in this case, 3- to 6-year-olds; Buren et al., 2021). Nine hundred and twenty-two adults in Germany (music educators and musicians, educators but without specialization in music, parents and carers) rated the 49 resulting statements according to how frequently they thought a musical child between the ages of 3 and 6 exhibited these behaviors. Similar to Hallam's (2010) results, a differentiated and multifaceted picture of musicality emerged. Through PCA analysis, four components of children's musical abilities and behaviors were identified: (1) Musical Communication, (2) Enthusiasm and Motivation (the affinity and the enjoyment of music and the motivation to make music), (3) Analytical Understanding (the awareness of different aspects of music and the use of this knowledge to evaluate music), and (4) Musical Abilities (audiation abilities and the integration of these abilities for making music). On average, participants rated enthusiasm and motivation as the most important indicators of musicality in childhood, followed by musical abilities like audiation skills. Musical and educational training of the survey participants only affected the ratings on the component Analytical Understanding. The analytical understanding of 3- to 6-year-olds was considered more important by parents and carers than by educators, while music educators and musicians attributed the least importance to this component.

Since children under the age of 3 years have specific cognitive, motor, and emotional prerequisites (Bukatko and Daehler, 2004; Siegler et al., 2014; Berk, 2018), it remains unclear whether the conceptions of musicality in childhood (between 3 and 6 years) extend to children under the age of 3 years. Hence, it seems highly likely that adults would assess musicality in children under 3 years of age according to differing criteria.

For example, in terms of the component Musical Communication, it is unclear whether it is seen as equally important in children under 3 years of age, because musical vocalizations before 2 years of age are hard to distinguish from preverbal vocalizations (Stadler Elmer, 2012). Since the components Analytical Understanding and Musical Abilities are also heavily influenced by basic cognitive and linguistic skills, it remains to be seen whether they are also considered important for conceptions of musicality in children under 3 years. Furthermore, the component of musical abilities may also play a different role in younger children, since musical production skills in particular (e.g., tapping, drumming) are strongly dependent on age-related motor development processes.

The aim of this study was to draw a more comprehensive picture of infant musicality which will allow us to develop meaningful, reliable, and objective test procedures for musicality that build on a clear operational definition of the construct being measured. In addition to approaching musicality from a theoretical perspective, the empirical approach pursued in this study can confirm and complement assumptions derived from theories on musical development (e.g., Swanwick and Tillman, 1986; Serafine, 1988; Hargreaves and Galton, 1992; Gordon, 2007; Ockelford, 2013). The everyday experience of parents and educators can provide added value that can serve to refine theories. Theoretical approaches, such as general factor or multifactorial approaches, serve to systematize in a meaningful way, but should also stand up to empirical scrutiny.

In the present study, we investigated how German adults from different professional backgrounds and with a range of musical expertise perceive the construct musicality in early childhood. More specifically, we were interested in their assessment of behavioral indicators and personal factors that might be considered expressions of musicality. To this end, we created a questionnaire that contained statements about musical abilities and behaviors and asked participants with varying professional and musical backgrounds to rate these statements, according to how well they thought the statement described musicality in under-3-year-olds. The results of this study can serve as a basis for the development of a musicality test that does not reduce musicality to individual aspects, but reflects a more comprehensive understanding of musical behavior.

MATERIALS AND METHODS

Participants

The sample comprised 221 participants between 20 and 69 years (M = 38.97, SD = 8.89) who indicated that they regularly spend time with children under the age of 3 years. Participants were excluded if they had filled in less than 50% of the questionnaire items (n = 29), if they had given constant ratings to all items (n = 9), or if they took less than 4 minutes to complete the entire survey (n = 9), resulting in a sample of 174 valid cases. Out of those, 146 were female and 66 had a university degree (of which n = 21 had a degree in music), 50 had the equivalent of A-levels, 50 had the equivalent of a general secondary school leaving certificate and 8 had a lower secondary school leaving

certificate or no certificate at all. The final sample included 76 early childhood educators and 96 parents and carers without professional training in pedagogy or music education. Two participants did not indicate their profession.

Materials

The Musical Child Questionnaire for Infants and Toddlers (MCQ_U3)

The Musical Child Questionnaire for children under 3 years (MCQ_U3) is an adapted version of the Musical Child Questionnaire (MCQ), which was developed to assess conceptions of musicality in children between 3 and 6 years of age (Buren et al., 2021). The basis for the development of both questionnaires was a survey by Hallam and Prince (2003) where participants had to complete the sentence: "musical ability is..." Statements were translated into German and adapted for the use with children from 0 to 3 years by adjusting to the ability spectrum of this age group. For example, the phrase "being able to move in time with a rhythm" (Hallam and Prince, 2003) was transformed to "A musical child under 3 years is able to move according to the music." All decisions regarding the reformulation or elimination of items were made by consensus of all authors. The final version of the Musical Infant/Toddler Questionnaire consisted of 41 statements describing musical abilities and behaviors in infants and toddlers. Participants rated on a 5-point-Likert-scale (ranging from 1 = rarely/never to 5 = always) how often a child under the age of 3 years that they considered as "musical" would typically show these behaviors.

The Goldsmiths Musical Sophistication Index

To assess the musical background of all survey participants, they were asked to complete the seven-item musical training subscale of the Goldsmiths Musical Sophistication Index (Gold-MSI; Müllensiefen et al., 2014) in its German version (Schaal et al., 2014).

Demographic Information

All participants provided information about their age, gender, educational background, and profession.

Procedure

Data were collected between April 2019 and June 2020 in Germany. Most of the respondents were recruited online using e-mail distribution lists from music schools, day care centers and the panel of a market research agency. The study was approved by the Ethics Council of the Max Planck Society, and informed consent was obtained from all participants.

Analytic Strategy

Data analyses were performed using the R software environment (R Core Team, 2019), including the R packages psych (Revelle, 2020) and lavaan (Rosseel, 2012).

The main goal of the data analyses was to identify distinguishable facets of musical abilities and behaviors in infants/toddlers, and to compare these to the facets of musical behaviors previously identified in children between 3 and 6 years (Buren et al., 2021). As a first step, the grouping structure of the data was explored by computing a series of principal component analyses (PCA) and comparing solutions to the model previously established for children from 3 to 6 years by confirmatory factor analysis.

In a second step, a shorter scale of the MCQ_U3 with better psychometric properties was constructed using PCA. Differences in scale scores were then investigated with respect to participants' levels of musical or educational training through correlations and multivariate analysis of variance.

RESULTS

Descriptive Analysis

Table 1 lists the top 10 items that were rated by the participants as the most frequent indicators of musicality in children under 3 years of age. Interestingly, the seven items with the highest mean values are similar in content. These statements describe a high interest in music, enjoyment of music and the motivation to become musically active. The three remaining items in the top 10 list describe that a musical child has individual preferences in music taste and a "musical ear."

Grouping Items of the MCQ_U3

We computed three PCA models to group the items of the MCQ_U3 into different components. The first grouping was computed following Hallam's (2010) analysis strategy, retaining all PCA components with Eigenvalues above 2 and applying varimax rotation. The resulting model comprised 2 components and explained 44% of the variance (see **Table 2** for the root mean square of the residuals). As an alternative, parallel analysis (Horn, 1965) was used to determine the number of PCA components which generated a 2-component solution to which oblimin rotation was applied. The resulting model also explained 44% of variance. Last, we specified a 4-component model with oblimin rotation to investigate similarities to the model previously established for children from 3–6 years (Buren et al., 2021). This solution explained 52% of the item variance.

All three models were compared using confirmatory factor analysis along with the previously established model for 3–6-year-olds (Buren et al., 2021). Fit indices are shown in **Table 2**.

Both 2-component-solutions were highly similar in content as well as in their fit indices. The 4-component PCA model proved to have the best model-data-fit, according to the Bayesian information criterion (BIC). Because both the relative (TLI, CFI) and absolute fit indices (RMSEA, SRMR) for this model were also in an acceptable to good range, we decided to select the 4-component-model for content interpretation (see **Table 3** for items and their loadings).

The first component included items that reflected types of musical communication (e.g., "A child under 3 years who is musically skilled can communicate with others through music by producing musical sounds, listening, improvising, dancing, and understanding music"), or musical understanding (e.g., "A child under 3 years who is musically skilled shows that he/she can capture patterns when dancing or

TABLE 1 | Highest rated items of the Musical Infant/Toddler Questionnaire (MCQ_U3).

Item no.	A child under 3 years who is musically skilled. . .	*M*	*SD*
43_U3	. . . enjoys the occupation with music.	4.20	0.78
38_U3	. . . is interested in music.	4.16	0.85
41_U3	. . . has great enthusiasm for music.	4.09	0.81
14_U3	. . . enjoys music in his/her life, either by making music or by listening to it.	4.05	0.87
45_U3	. . . has a great affinity for music.	3.94	0.84
15_U3	. . . enjoys music and appreciates sounds.	3.88	0.89
29_U3	. . . has the desire to make music together with others so that they become a group–either by singing along or moving to the music of others.	3.76	0.99
42_U3	. . . has a will of his/her own when listening and making music.	3.70	0.98
21_U3	. . . knows which music he/she likes and which he/she does not like.	3.70	1.08
1_U3	. . . has a musical ear, which means he/she can recognize simple melodies and tone progressions.	3.70	0.90

TABLE 2 | Fit indices of computed models.

	BIC	TLI	CFI	RMSEA	SRMR
2-component PCA (following Hallam, varimax rotated)	17520.93	0.778	0.790	0.074	0.070
2-component PCA (parallel analysis, oblimin rotated)	17518.47	0.778	0.790	0.074	0.070
4-component PCA (according to grouping in 3–6-year-olds, oblimin rotated)	17568.80	0.767	0.781	0.076	0.074
4-component PCA (parallel analysis, under-3-year-olds, oblimin rotated)	**17481.65**	**0.793**	**0.805**	**0.072**	**0.070**

BIC, Bayesian Information Criterion; TLI, robust Tucker-Lewis Index; CFI, robust comparative fit index; RMSEA, robust root mean square error of approximation; SRMR, standardized root square residual.
The selected model is displayed in bold.

making music") or the ability to express oneself through music (e.g., "A child under 3 years who is musically skilled can invent melodies or rhythms, either with the voice, or by creating other sounds"). This component included factor loadings ranging from 0.40 to 0.57 and was termed Musical Communication.

The second component contained 15 items with loadings ranging from 0.31 to 0.85. We named this component Enthusiasm and Motivation, because many high loading items described general interest in music (e.g., "A child under 3 years who is musically skilled has great enthusiasm for music") and the inherent motivation to become musically active (e.g., "A child under 3 years who is musically skilled often has the desire to make music"). Also associated with this component were items on creativity, playing with feeling, and having one's own taste in music.

Component 3 was interpreted as Adaptive Expressiveness. This component described the ability of a musical child to respond flexibly to different types of music, to appreciate different kinds of music and to react correspondingly in creative, emotional, and intellectual ways. It comprised factor loadings from 0.38 to 0.74.

Component 4 was composed of 10 items (component loadings ranged from 0.34 to 0.75) focusing on musical abilities in a more specific sense (e.g., having a musical ear and a sense of timing, rhythm, and beat). It also contained items describing a set of more global abilities and behaviors (e.g., "A child under 3 years who is musically skilled has a wide range of different skills"; ". . .is able to combine hearing and sound production"). Therefore, we named the component Musical Abilities. **Table 4** shows the mean ratings and the amount of explained variance by component.

Constructing the MCQ_U3 Short Scale

Grouping the items of the MCQ_U3 provided an informative classification suggesting four different facets of young children's musicality. In a next step, we constructed a short scale of the MCQ_U3 to obtain a more robust and practical measurement instrument for use in future studies.

The short scale was constructed using parallel analysis with PCA and subsequent oblimin rotation. Then, only items with component loadings of >0.4 were retained in order to reduce the number of items and maximize their discriminatory power. This resulted in a 2-component solution, which included 26 items and explained 51% of the variance (see **Table 5** for the retained items and their respective loadings). The first component comprised a diverse set of items on perceptual and productive musical abilities and was therefore named Basic Musical Abilities (it contained items from the 3 components Musical Communication, Adaptive Expressiveness, and Musical Abilities of the 4-component solution). The second component included items on motivation, interest, and enthusiasm. Therefore, we kept the name Enthusiasm and Motivation.

Professional Background and Musical Expertise Associated With Differences in the Evaluation of Musicality

Through regression, we computed the component scores for all participants. Subsequently, we explored the influence of profession using a multivariate analysis of variance with professional background (professional educators, parents, and caregivers) as the independent variable and the two component scores as dependent variables. The test revealed no significant

TABLE 3 | Items of the Musical Infant/Toddler Questionnaire (MCQ_U3), grouped by components.

	MCQ_U3 item			Component loading			
Item no.	**A child under 3 years who is musically skilled. . .**	***M***	***SD***	**1**	**2**	**3**	**4**
Component 1: Musical Communication							
2_U3	. . . can sing simple melody pieces.	3.47	1.09	0.57	0.41	−0.17	0.05
30_U3	. . . can invent melodies or rhythms, either with the voice, or by creating other sounds.	3.31	1.08	0.53	0.11	0.26	0.03
3_U3	. . . is able to internalize simple sound sequences.	3.44	0.96	0.47	0.11	0.08	0.36
8_U3	. . . shows that he/she can capture patterns when dancing or making music.	3.32	0.10	0.47	0.11	0.05	0.36
27_U3	. . . can communicate with others through music by producing musical sounds, listening, improvising, dancing, and understanding music.	3.24	1.05	0.40	0.13	0.36	0.07
Component 2: Enthusiasm and Motivation							
41_U3	. . . has great enthusiasm for music.	4.09	0.81	0.03	0.85	0.04	−0.14
38_U3	. . . is interested in music.	4.16	0.85	−0.08	0.75	0.07	0.08
43_U3	. . . enjoys the occupation with music.	4.20	0.78	0.04	0.75	0.04	−0.04
14_U3	. . . enjoys music in his/her life, either by making music or by listening to it.	4.05	0.87	0.07	0.72	−0.24	0.22
39_U3	. . . often has the desire to make music.	3.67	0.93	0.01	0.67	0.10	0.02
45_U3	. . . has a great affinity for music.	3.94	0.84	−0.11	0.60	−0.06	0.35
15_U3	. . . enjoys music and appreciates sounds.	3.88	0.89	0.05	0.56	0.18	0.03
31_U3	. . . likes to spontaneously produce music or musical sounds.	3.68	0.93	0.20	0.56	0.21	0.04
29_U3	. . . has the desire to make music together with others so that they become a group – either by singing along or moving to the music of others.	3.76	0.99	−0.07	0.51	−0.21	0.35
42_U3	. . . has a will of his/her own when listening and making music.	3.70	0.98	0.23	0.51	0.15	−0.03
10_U3	. . . actively incorporates music into his/her world.	3.49	0.98	0.24	0.50	0.27	−0.02
25_U3	. . . plays music with feeling.	3.57	1.08	0.30	0.47	0.16	0.01
32_U3	. . . is creative when making music.	3.57	1.03	0.38	0.42	0.18	−0.07
9_U3	. . . recognizes simple structural characteristics of music (e.g., loud–soft, slow–fast).	3.64	0.93	0.40	0.41	0.03	0.08
21_U3	. . . knows which music he/she likes and which he/she does not like.	3.70	1.08	0.28	0.31	0.04	0.10
Component 3: Adaptive Expressiveness							
44_U3	. . . would rather express themselves through music than through other means.	2.58	1.06	0.06	0.00	0.74	−0.02
17_U3	. . . appreciates different kinds of music.	3.08	1.01	−0.18	0.18	0.65	0.13
26_U3	. . . perceives the basic mood or feelings conveyed by the music that he/she is listening to.	3.10	0.99	−0.02	0.08	0.64	0.21
11_U3	. . . is able to react to the mood of a melody.	3.22	1.03	0.06	0.03	0.64	0.23
22_U3	. . . is able to hear differences between different types of music.	3.04	1.07	0.23	−0.06	0.56	0.14
46_U3	A child is musical when music means something to him/her.	3.23	1.12	−0.37	0.32	0.51	0.08
16_U3	. . . has an open mind with which he/she approaches and experiences all music.	3.40	1.00	−0.06	0.48	0.51	−0.23
18_U3	. . . recognizes different types of music (e.g., children's songs, pop, classical music).	2.77	1.22	0.28	−0.20	0.49	0.09
13_U3	. . . is able to react creatively, emotionally and intellectually when listening to a piece of music.	3.24	1.04	0.35	0.08	0.47	0.06
19_U3	. . . reacts consciously to different aspects of music.	3.26	1.03	0.39	−0.12	0.46	0.15
47_U3	. . . can immerse him-/herself in sounds.	3.11	1.08	0.20	0.31	0.38	0.13
Component 4: Musical Abilities							
6_U3	. . . has a sense of timing and rhythm.	3.41	1.04	0.14	−0.04	−0.01	0.75
24_U3	. . . has good overall physical coordination.	3.19	0.91	−0.11	0.00	0.08	0.69
36_U3	. . . has a wide range of different skills.	3.35	0.96	−0.08	−0.10	0.28	0.58
12_U3	. . . is able to move according to the music.	3.51	0.93	−0.15	0.33	0.11	0.47
7_U3	. . . has a feeling for the beat.	3.26	1.01	0.22	0.00	0.22	0.46
1_U3	. . . has a musical ear, which means he/she can recognize simple melodies and tone progressions.	3.70	0.90	0.37	0.09	0.09	0.45
35_U3	. . . is able to combine hearing and sound production.	3.68	0.88	0.17	0.02	0.18	0.42
4_U3	. . . has good hearing ability.	3.63	0.90	−0.04	0.23	0.21	0.42
20_U3	. . . likes listening to music and finds matching gestures or movements.	3.63	0.88	0.06	0.29	0.07	0.40
5_U3	. . . has a good memory for patterns.	3.28	0.98	0.17	0.29	0.18	0.34

relationship between professional educators and parents and carers [$V = 0.31$, $F(2, 166) = 2.63$, $p = 0.08$, partial $\eta^2 = 0.031$], suggesting that a professional background in child education did not influence the conceptions of musicality in infants/toddlers. However, the correlations between the Gold-MSI musical training subscale and the components Basic Musical Abilities

TABLE 4 | Mean ratings grouped by components.

	M	*SD*	*n*	Number of items included	Explained variance (%)
Musical Communication	3.36	0.77	174	5	9
Enthusiasm and Motivation	3.81	0.64	174	15	18
Adaptive Expressiveness	3.12	0.72	174	11	14
Musical Abilities	3.47	0.62	174	10	11

SD, Standard Deviation; n, number of participants.

($r = 0.26$, $p = 0.001$) and Enthusiasm and Motivation ($r = 0.27$, $p < 0.001$) of the MCQ_U3 short scale, were significant and of low to moderate strength, indicating that musical expertise is associated with slightly higher ratings on both components.

Differences Between Conceptions of Musicality in Infants/Toddlers (<3 Years) and Older Children (3–6 Years)

Inspection of item overlap on the short scales (MCQ vs. MCQ_U3) showed that the component Musical Communication (MCQ) did not have any equivalent in the MCQ_U3. Furthermore, the components Analytical Understanding and Musical Abilities (MCQ) were combined into one component of the MCQ_U3 (Basic Musical Abilities). The component Enthusiasm and Motivation was highly similar in both short scales. The high content similarity was also reflected in a high Rand Index (a measure of similarity between two data clusterings; RI = 0.83, RI adjusted for chance = 0.65). This means that items that were grouped into one component in the version for older children fall mostly into one component in the version for younger children as well.

DISCUSSION

This study explored the origins of musical behavior in early childhood. To this end, we investigated how German adults conceptualize musicality in children under the age of 3 years. More specifically, we were interested in which facets of the construct musicality are considered important by people with different professional and musical experience and whether these facets coincide with those that can be assessed using common musicality tests. Through PCA analysis, we identified four components of musicality in early childhood: Musical Communication, Enthusiasm and Motivation, Adaptive Expressiveness, and Musical Abilities. Interestingly, only this last component reflects traditional conceptions of musicality that strongly relate to aural abilities (we named this component Musical Abilities), whereas the three remaining components dealt with elements not traditionally captured by musical ability tests. Our results are largely consistent with previous findings on musicality in 3- to 6-year-old children (Buren et al., 2021). Thus, three components in the current study were broadly similar to those in the previous study of musicality in 3- to 6-year-old children (Musical Communication, Enthusiasm and Motivation, Musical Abilities). However, we were also able to show that the facets are not completely alike. Thus, the component Analytical Understanding of Music is not found in the under-3-year-olds. Instead, we found the facet Adaptive Expressiveness, which was not part of musicality in older children.

The Adaptive Expressiveness component was found to represent emotional facets of musicality. These include the ability to perceive and respond to the mood of musical stimuli. The component represents the ways in which children adapt their expressive reactions to different aspects of the music. In addition, items of this component indicate that children who are considered musical are open-minded to all types of music and recognize and appreciate different kinds of music. Analytical Understanding of Music, which was a component of musicality conceptions in older children (Buren et al., 2021), probably does not yet play a role in younger children because of developmental differences. Younger children seem to have a more spontaneous and intuitive access to music, whereas in older children the access to music may have become more analytical and includes a cognitive understanding as well.

On average, enthusiasm for music and the motivation to become musically active was rated by all participants as the most important sign of musicality in children under 3 years of age. This is in line with previous conceptions of child musicality in children older than 3 years (Buren et al., 2021). This suggests that enthusiasm for music is seen as a foundation for musical skill development. Although almost all infants generally show interest in musical stimuli and activities, interindividual differences in musical enthusiasm and motivation could be interpreted as indicators of musicality. These interindividual differences in musical interest might also be linked to the Big Five personality trait openness-to-experience which has been associated with aesthetic interest (McManus and Furnham, 2006) and musical engagement in both children and adults (Corrigall et al., 2013; Müllensiefen et al., 2014). The assumption that motivation predicts musical achievement is also evident in the observation that motivational factors are often used as criteria for selecting musical talent among students (Haroutounian, 2000). Motivation has also been conceptualized as a facet of musicianship in adulthood, recognizing the importance of deliberate effort in the development of musical expertise (Hallam, 2010).

Nevertheless, the measurement of motivational aspects has not yet been given much attention in the scientific assessment of musicality. Perhaps this is the result of methodological difficulties in the measurement of motivational aspects or is a reflection of the concern that motivation may be short-lived (Karma, 2007). However, because enthusiasm and motivation seem to be crucial components of musicality, we need valid measurements, questionnaires, or systematic observations to gain further insight into their importance for musical ability development.

The component Musical Abilities reflects traditional conceptions of musical ability relating to audiation, as assessed by traditional musicality tests. Examples include having a sense of timing and rhythm, a feeling for the beat, and a good musical ear. Additionally, some items describe the ability to move in time with music and find

TABLE 5 | Short scale of the Musical Infant/Toddler Questionnaire grouped by components.

	MCQ_U3 item	Component loading	
Item no.	**A child under 3 years who is musically skilled. . .**	**1**	**2**
Component 1: Basic Musical Abilities			
19_U3	. . . reacts consciously to different aspects of music.	0.78	−0.19
22_U3	. . . is able to hear differences between different types of music.	0.75	−0.11
11_U3	. . . is able to react to the mood of a melody.	0.74	−0.02
3_U3	. . . is able to internalize simple sound sequences.	0.72	0.03
8_U3	. . . shows that he/she can capture patterns when dancing or making music.	0.68	0.04
7_U3	. . . has a feeling for the beat.	0.67	−0.05
13_U3	. . . is able to react creatively, emotionally and intellectually when listening to a piece of music.	0.67	0.04
26_U3	. . . perceives the basic mood or feelings conveyed by the music that he/she is listening to.	0.67	0.04
1_U3	. . . has a musical ear, which means he/she can recognize simple melodies and tone progressions.	0.66	0.06
27_U3	. . . can communicate with others through music by producing musical sounds, listening, improvising, dancing, and understanding music.	0.65	0.09
30_U3	. . . can invent melodies or rhythms, either with the voice, or by creating other sounds.	0.65	0.04
47_U3	. . . can immerse him-/herself in sounds.	0.58	0.25
5_U3	. . . has a good memory for patterns.	0.56	0.22
9_U3	. . . recognizes simple structural characteristics of music (e.g., loud–soft, slow–fast).	0.42	0.33
Component 2: Enthusiasm and Motivation			
41_U3	. . . has great enthusiasm for music.	−0.11	0.90
14_U3	. . . enjoys music in his/her life, either by making music or by listening to it.	−0.10	0.82
38_U3	. . . is interested in music.	0.03	0.77
43_U3	. . . enjoys the occupation with music.	0.00	0.75
39_U3	. . . often has the desire to make music.	0.04	0.69
45_U3	. . . has a great affinity for music.	0.05	0.68
15_U3	. . . enjoys music and appreciates sounds.	0.19	0.56
31_U3	. . . likes to spontaneously produce music or musical sounds.	0.34	0.55
10_U3	. . . actively incorporates music into his/her world.	0.37	0.48
42_U3	. . . has a will of his/her own when listening and making music.	0.28	0.47
32_U3	. . . is creative when making music.	0.31	0.44
25_U3	. . . plays music with feeling.	0.37	0.42

matching gestures and movements. This shows that musicality is not limited to perceptual musical skills, but is rather perceived as diverse and multiform, involving motor skills and the integration of skills across senses. Even in very young children our results demonstrate the complexity of musical behaviors.

The component Musical Communication focuses on using music for communicative purposes. To communicate musically, infants need a considerable "toolbox" for the perception and stimulation of communicative signals (Malloch, 2000). Hence, on the one hand, the component included items on the ability to capture and internalize musical stimuli; on the other hand it included the ability to invent melodies or rhythms, produce musical sounds, rhythmic movements, or sing.

Reducing the items for the short scale of the MCQ_U3 resulted in a 2-component model in which the Enthusiasm and Motivation component remained stable in content and the remaining three components were combined into one component (which we named Basic Musical Abilities). The component Basic Musical Abilities should thus be understood as something significantly more complex than what conventional measures of musical ability capture, which underpins the need for additional measures that cover a broader range of abilities and behaviors.

Using the short scale, we found that professional training in education or professional experience as an educator had no significant effect on the ratings of either component which stands in contrast to previous findings (although participants with more musical training gave slightly higher ratings on both components). In general, our results suggest that there is a high level of agreement about what constitutes musicality in young children.

Adult caregivers shape children's musical environment and their conception of childhood musicality forms the basis of their musical nurturing and education. Therefore, it is important to understand how adults view children's musicality, because musical interactions between caregiver and infant contribute to the infant's musical development in a meaningful way. Our study has shown that parents and carers are aware of motivational aspects being a key component in musical development. It remains unclear if they are aware of ways to foster their children's motivation. Many parents might be unaware of their own musicality and might rely on recorded music or institutional learning to develop their child's musical skills (Trehub, 2015).

Limitations and Future Directions

Finally, potential limitations need to be considered. Our questionnaire was based on statements obtained from a qualitative study of conceptions of musicality in adults (Hallam and Prince, 2003). We conscientiously adjusted the statements to reflect conditions in childhood. However, because the original study focused on musicality in adulthood, the original responses may not have included all aspects of musicality in under-3-year-olds. Nevertheless, the high level of agreement with the selected statements showed that the used items, in general, reflected the conceptions of our sample.

The focus on social conceptions of musicality entails the limitation that the results may be restricted to a German population or Western music cultures. In particular, these conceptions may relate to children's experiences and opportunities. It has been shown that the musical abilities of infants/toddlers and preschoolers differ significantly and that parents and caregivers perceive this accordingly and adjust their musical endeavors (Politimou et al., 2018). Thus, the environment strongly influences the musical behaviors exhibited and, consequently, the conceptions of musicality. In addition, the selected age range (0–3 years) is associated with large developmental changes. Some items were therefore not necessarily suitable for children across the full age range (some behaviors may not yet be exhibited by the youngest children). Here, a more precise differentiation could provide a clearer picture. Nevertheless, we think that our results are a first step toward capturing social constructs of musicality in very young children. Based on our results, however, finer classifications should be chosen for further studies and test development in order to better reflect developmental aspects.

Another future goal is to use the identified conceptions as a basis for examining childhood musicality and to explore whether this framework can be used to develop and validate test procedures as well as rating scales that reflect the social construct of musicality and, in so doing, trace the nature of musicality.

Hopefully, such test procedures will help to sketch out a more complete and comprehensive picture of musical development. Moreover, they could serve to identify individual differences in musical development between children.

At the moment we tend to draw our conclusions from sample averages rather than individual data (Sloboda, 2008). A key problem of these studies is, however, that their results tell us little about how individual developmental trajectories are shaped, because this information can get lost in aggregated values (Sloboda, 2008).

Practical Implications

The results of this study illustrate the complexity and multi-layered nature of musicality — even among the very young. Furthermore, we were able to show that conceptions of musicality are differentiated and adapted to musical and general developmental levels. In line with previous studies, the results also point to the great importance of enthusiasm and motivation for musical development processes. Given that everyone has some degree of musical potential (Gordon, 1987; Gembris, 1997; Honing, 2018), what can be done to help children to nurture their individual gifts? There is evidence that a musically enriched environment in which music is appreciated and enjoyed is critical for future development of musical ability (Shuter-Dyson, 1999) and may help children to develop a positive musical self-concept and motivation to develop their skills (Sloboda et al., 1994). The promotion of musical development must therefore not be limited to music lessons, but should explicitly include supposedly "ordinary" activities such as singing with the child (Papoušek, 1982; Trevarthen and Malloch, 2002). The importance of these experiences as learning opportunities may be greatly underestimated (Papoušek, 1982). Parents and caregivers (or educators) can thus promote musicality by interacting musically with children, stimulating their musical interests, and providing them with joyful musical experiences. Hence, early years musical development can be supported by acknowledging the spontaneous musical outputs of young children (e.g., rhythmic movements, cooperative singing) and responding to them. Such interactive forms of musical communication may be very effective in supporting children's enthusiasm and motivation for music (Flohr and Trevarthen, 2008).

CONCLUSION

This study is a first step toward enhancing a general understanding of conceptions of musicality in children under 3 years. We were able to show that already in early childhood, a multifaceted picture of musicality prevails. In particular, adaptive expressiveness, the ability to react flexibly to different musical stimuli, was shown for the first time to be a component of musicality. Furthermore, the results have highlighted the role of enthusiasm and motivation even in the youngest age group and have corroborated earlier findings that conceptions of musicality are broad and multifaceted. This reinforces the notion that traditional musical ability tests can only capture a limited portion of musicality and should therefore be supplemented by new assessment procedures, questionnaires, or observational measurement instruments. In the long run, a more comprehensive view and assessment of musicality may lead to an in-depth understanding of individual musical developmental trajectories and a better means of support for musical development.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Council of the Max Planck Society. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TR and VB contributed to the data collection. VB performed the literature search and drafted the manuscript. VB and DM performed the statistical analysis. FD and DM provided the critical revisions. All authors contributed equally in the project's conception and design of the questionnaire, contributed to the article, and approved the submitted version.

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STUDY 3:

SCREENING MUSICALITY IN CHILDREN: DEVELOPMENT AND INITIAL VALIDATION OF A NEW TOOL FOR RAPID ASSESSMENT OF MUSICAL PROFILES

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RESEARCH ARTICLE

Screening musicality in children: Development and initial validation of a new tool for rapid assessment of musical profiles

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Abstract

Musical development in childhood follows universal trajectories, such as the acquisition of basic rhythm and pitch recognition, alongside individual differences shaped by environmental, educational, and innate factors. Despite the importance of understanding these aspects for both research and educational purposes, there remains a significant gap in the availability of validated tools that can quickly and comprehensively assess musicality in children. To address this gap, this paper presents a series of studies on the development and validation of the Child Musicality Screening, a standardised instrument for the assessment of musicality in children aged 3 to 10 years. In Study 1, an initial pool of items was compiled and administered to 810 adults (293 English-speaking, 517 German-speaking) who regularly interact with children. Factor analysis was used to reduce the number of items and to identify three key dimensions of child musicality: *Enthusiasm and Motivation*, *Music Perception*, and *Music Production*. In Study 2, confirmatory factor analysis on ratings of parents (n = 305) and educators (n = 250) indicated moderate to high model fit, confirming the factor structure of the questionnaire. Interrater agreement between parents and educators was significant, with moderate agreement on the total scale and subscales. Preliminary evidence of convergent and divergent validity was also obtained. Study 3 further established the convergent and divergent validity, as well as internal reliability and test-retest reliability, of the instrument, using both English (n = 323) and German (n = 384) samples. Overall, the Child Musicality Screening is a newly developed tool for assessing individual musical profiles in children aged 3 to 10 years, with initial evidence supporting its validity and reliability. Available in both English and German, it offers a promising approach for researchers and educators to assess musicality, map developmental trajectories, identify musically gifted children, and enhance targeted music education.

Introduction

Scientific studies of musical development have generated extensive and remarkable knowledge on the emergence and development of musical perception and production abilities (for a comprehensive review, see [1]). These studies mainly focused on identifying general

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developmental trends, often delineated by age-related milestones. In recent years, however, there has been a growing emphasis on individual differences in musical development, with attention shifting to variations in ability profiles [e.g., 2–4]. It is increasingly recognised that musical abilities vary between children and do not necessarily develop at the same pace, with substantial individual differences [2].

In addition to evolving research priorities, a major challenge in musical development research is the lack of clear and common construct definitions [5], which complicates the generalisation of results across studies. This issue stems from the inherently multifaceted nature of musicality and the resulting variety of methods and measures employed [6]. Recent efforts have responded to this challenge by conceptualising musicality as a social construct, acknowledging its contextual variability across different cultures, subgroups, and individuals [5,7]. The results of these studies suggest that conceptions of musicality in both adulthood [5] and childhood [7,8] encompass a broader range of skills and behaviours than those typically assessed by traditional musicality tests, which often focus on music perception skills, such as the discrimination of simple musical parameters. Indeed, conceptions of children's musicality held by parents, educators, and other stakeholders invested in music education extend beyond musical abilities in the narrower sense (perception and production skills) to include facets such as enthusiasm and motivation, musical communication, and analytical understanding of music as important indicators of musicality in childhood [7].

However, this broader conception of musicality has not yet led to the development of corresponding measurement instruments for rapid and scalable screening of general musicality in children that are psychometrically robust and construct-validated. While the Gold Musical Sophistication Index (Gold-MSI) provides a comprehensive measure for assessing musicality in adults [9], few comparable instruments exist for evaluating child musicality. For instance, the Child Musical Behaviour Inventory [CMBI; 10] provides a comprehensive yet fairly lengthy measure for assessing musical behaviour in children under the age of 5 years, while the Music@Home questionnaire [M@H; 11] is specifically designed to assess children´s musical home environments. However, research still lacks reliable and valid measures that are both rapid to administer and able to capture the multifaceted nature of musicality across larger parts of childhood [7].

To address this gap, this study aims to develop a standardized brief screening instrument for the assessment of musicality in children aged 3 to 10 years, that is based on a comprehensive understanding of musicality, meets common psychometric criteria, and is suitable for mapping individual developmental trajectories.

Musical development in childhood

Every human being has an innate potential or talent to develop musical skills and abilities [12]. Hence, all children have the potential to express themselves musically [13]. However, from the very beginning, developmental processes are driven by enculturation and training [14]. From the very beginning, developmental processes are shaped by socialisation, which encompasses both cultural and social aspects. Musical enculturation, as a part of socialisation, refers to the implicit and effortless acquisition of musical competence through everyday exposure to the forms of music that are typical for the culture one is born into [12]. In contrast, musical training involves formal learning through structured education and practice [15]. In infancy and early childhood, enculturation predominates and active training plays a secondary role [16].

From the third trimester of pregnancy, the foetus is able to perceive and process auditory stimuli [17]. After birth, children already possess a surprisingly sophisticated perception ability: infants are competent music listeners. For example, new-borns and young infants

can discriminate simple rhythmic patterns [18–20], and two-month-olds can discriminate between melodies of different length [19]. In terms of pitch processing, sensitivity to melodic contour and relative pitch emerges in early infancy [21], while sensitivity to harmony reaches adult-like performance levels in later childhood [e.g., 22]. Recent research indicates that the development of production skills builds on perceptual skills and progresses throughout childhood [23]. While production skills emerge later than perceptual skills, they are already evident from early stages of development. Precursors of music production emerge before a child's first birthday, including rhythmic movements in response to music and early song-like vocalisations [24,25]. In their musical development infants are universalists, meaning that they are perceptually equipped for music from any culture [26]. Their resolution of pitch [27] and timing [28] allows them to detect the smallest musically meaningful differences from their own culture and others [12,29]. During the first year of life, infants become attuned to the music that surrounds them and become increasingly proficient with patterns from their native culture [29].

By the time children enter school at around the age of 6 years, they demonstrate fundamental universal and basic culture-specific musical competence [21]. Commonplace musical competence is acquired effortlessly [12] through everyday musical interaction such as singing songs, dancing, playing musical games, and exposure to recorded music [11], for a review, see [30]. These musical interactions are frequent and highly complex [31], and the quantity and quality of informal musical activities may have specific influence on children's social, cognitive and language skills [11].

Children first develop basic music competencies, such as the sensitivity to melodic contour and relative pitch [21], as well as the ability to discriminate simple rhythmic patterns [18–20]. During primary school age, they achieve greater perceptual sophistication and complexity [32], including recognising more subtle pitch and sound characteristics [e.g., [32,33]. Additionally, tempo discrimination [34] and the ability to adapt to changes in meter [35] improve significantly. Production skills also advance during this period, as evidenced by greater accuracy in keeping a steady beat [36] and synchronized tapping [34]. Enculturation is complete at around the age of 10 to 12 years of age [16], when many music-related competencies are so well developed that they are similar to those of untrained adults [37]. Beyond enculturation, formal music training in the Global North often starts during kindergarten or primary school age [16]. These musical experiences, especially through instrument learning, can enlarge individual differences in the in the course of development [37]. In summary, some musical competencies are present from the very beginning of life, while others reach a higher level of knowledge and specialization only in older and musically experienced individuals [32].

While children universally acquire musical competencies and the basic principles of their development are increasingly understood, conclusions have predominantly been drawn from sample averages and aggregated values rather than individual data [38]. The traditional approach in developmental music psychology has largely centred on identifying common patterns, such as average improvements through music interventions or age-related average musical abilities in a given sample. Although this approach has been invaluable in advancing our understanding of general developmental trends, it may overlook the remarkable variability in individual developmental trajectories and the diverse manifestation of musical abilities.

Recent research on individual differences in musical ability has highlighted the roles of genetic factors and gene-environment interactions. It has been shown that even in individuals without formal musical training, musical ability (measured by a perception test) can reach musician-like levels and is associated with informal musical experience and performance on cognitive tests [39]. Furthermore, music perception ability was found to predict other variables such as recognising vocal emotions, regardless of musical training [40]. A musically

enriched childhood environment was also found to amplify individual differences, likely by providing opportunities that allow genetic factors to play a more prominent role in shaping outcomes [4]. These results challenge the view that learning and practice are the central origin of musical ability [41] by documenting genetic contributions to numerous aspects of musical abilities and behaviours in the general population.

In children, early musical ability was found to be associated with the duration of music training over the subsequent five years and to influence the likelihood of pursuing, adhering to, and benefiting from musical training [2]. Despite significant improvements in musical ability during this period, the stability in individual performance (in terms of who performed well or poorly) suggested that the impact of music training might be less significant than previously assumed [2]. Conversely, a study involving a large sample of children aged 9 to 17 years found that the amount of musical training did indeed positively affect the development of musical abilities over time [3].

This line of research underscores the importance of individual data in uncovering gene-environment contributions to musical ability, revealing that phenotypic musical ability results from a genetic profile that includes certain predispositions working in combination with environmental factors. Assessing individual musical profiles across different dimensions of musicality provides valuable insights into a child's strengths and potential areas for development, helping to better understand their unique musical trajectory. This approach contributes to our understanding of individual developmental pathways and underlying mechanisms, thereby filling a gap in current knowledge about musical development. However, this line of research also requires clear conceptions of musicality and measurement tools that meet stringent psychometric standards.

Conceptions of musicality

The assessment of musicality has been a research interest since at least the middle of the last century, yet consensus on the core components of musicality and their interrelationships remains elusive. Despite advancements in understanding the development of individual musical skills, the broader scope of developmental trajectories and the interconnectedness of these skills with the concept of musicality remain unclear.

A major challenge has been the lack of a precise definition of musicality or musical ability, which has led to the use of various test procedures based on different models of musicality. For example, the Seashore Measures of Musical Talent [42] are based on a multi-faceted conception of musicality, assuming that the musical profile of an individual consists of several and only loosely related aspects of musicality. Seashore used the term 'talents' and provided tests for, e.g., the discrimination of single pitches, short melodies, rhythms, etc. On the contrary, Bentley's Measures of Musical Abilities [43] assume that musical ability is best described by a general musical ability factor, assuming that all musical facets are substantially interrelated. These differences in conceptualisation can lead to extremely different music tests with some solely focusing on the sub-competencies that are considered fundamental by the test authors [44,45]. This, in turn, contributes to inconsistent psychometric results and low validity in existing measures [e.g., 45–48]. In addition to those conceptual issues, there has also been criticism of the tendency of testing procedures to overly focus on perceptual skills (e.g., same/different judgments of melodies or rhythms) and on aspects that are captured in music notation, while paying much less attention to production tasks, such as singing or tapping along to music. Furthermore, the majority of existing assessment batteries do not consider broader skills and behaviours such as musical communication, understanding, and motivation, that are considered highly critical for later musical development [49], thus limiting their

ability to provide a comprehensive approach that acknowledges the multifaceted nature of musical behaviour [6]. While practical considerations may partly explain this imbalance, the absence of a common concept of musicality has led to mixed results, that leave it unclear how different measures or scores relate to each other, limiting the ability to generalise across tasks and results [6].

Moreover, it is important to recognise that existing models and tests are predominantly Eurocentric or Western-oriented. This focus can limit the applicability and relevance of these assessments across different cultural contexts. One approach to overcome conceptual controversies is to consider musicality as a social construct, incorporating the assumption that musicality is not an inherent, universal quality, but rather a concept defined and redefined by society [5]. This implies taking into account the conceptions of musicality held by the general population, as well as by musicians and music educators from a specific period and region, thereby acknowledging the cultural specificity and the variability of such conceptions over time. In a series of studies, Hallam and colleagues have explored the conceptions of musicality held by people from different musical backgrounds [5,47,50,51]. In an initial qualitative study, Hallam and Prince [5] identified six overarching themes that adults and students associate with musicality, namely: aural skills, receptive activities, generative activities, the integration of a range of skills, personal qualities, and the debate about innate versus learned musical ability. Subsequently, Hallam used 77 statements generated from the qualitative study for a quantitative study of musical conceptions [51]. PCA analysis revealed six components of musicality: playing instruments or singing, musical communication, valuing and responding to music, composition and improvisation, commitment and motivation, and rhythmic ability and pitch understanding.

To explore whether these conceptions of musicality extend to childhood and infancy, Buren et al. [7] adapted the statements used by Hallam [51] to align with the abilities of 3- to 6-year-olds and 922 German adults rated the resulting 49 statements according to the frequency they believed a musical child would exhibit these behaviours. PCA analysis identified four components of children's musical abilities: Musical Communication, Enthusiasm and Motivation, Analytical Understanding, and Musical Abilities (in a narrower sense, i.e., perception and production skills). Only participants' ratings of analytical understanding were influenced by their musical and pedagogical training. For infancy and toddlerhood, three of the four components were replicated (Musical Communication, Enthusiasm and Motivation, and Musical Abilities) [8]. The component Analytical Understanding of Music was replaced by Adaptive Expressiveness for the younger ages, reflecting a less cognitive and more intuitive understanding of music. Although these components thus differ in their focus, they fundamentally measure a similar underlying concept. For younger children, Adaptive Expressiveness captures the spontaneous and instinctive ways they engage with music, whereas Analytical Understanding is more suited to older children who can cognitively process musical structures and concepts. In both studies, enthusiasm and motivation were consistently rated as the most significant indicators of musicality in childhood [7,8].

Taken together, these findings suggest that musicality as a social construct is multifaceted and that conceptions differ between adult and child musicality. While both conceptions of musicality emphasise the significance of musical communication and motivation besides musical abilities in a narrower sense, differences emerge in the complexity of the conceptions: while Hallam's research identified six components of musicality in adults [51], children's musicality appears to be constituted by only four distinct components [7]. Thus, when measuring musicality in childhood, it is important to recognise that qualitatively different abilities may play a role, and that the measurement should not be based solely on criteria used to assess musicality in adults. In addition, in order to accommodate a broader definition of musicality

into the assessment of musicality, it is important to consider a wide range of skills from an early age.

Questionnaires and screening tools on musicality in childhood

Incorporating the multifaceted nature of musicality into a standardised test or battery of tests presents a significant challenge, but questionnaires and screening tools offer a convenient and time-efficient means of capturing more complex behaviours. However, attempts in this direction are surprisingly scarce. The most prominent and widely adopted example of a questionnaire that is based on a broader understanding of musicality is the Goldsmiths Musical Sophistication Index (Gold-MSI), a self-report inventory for adults that assesses individual differences in musical sophistication in non-musicians [52]. For children, there is a slightly adapted version that has been validated for secondary school age [53]. However, self-reporting becomes increasingly difficult in earlier childhood. Therefore, it is common to rely on parent or educator assessments of child behaviour. Although this approach seems relatively straightforward, there have been limited attempts to develop measurement tools for assessing musical abilities and behaviours.

Currently, there are two parent-report questionnaires that explore musical practices in the home environment: The Home Musical Environment Scale [HOMES; 54], a fifteen-item questionnaire designed for parents of school-aged children and the Music@Home questionnaire [M@H; 11], available for parents of preschool children (2–5.5 years; 17 items) and infants (3–23 months; 18 items).

Focusing on educational implications, the Musical Development Matters Inventory [55] is a checklist designed to provide educational guidance by documenting various musical learning moments in early childhood development (from birth to 5 years). As the emphasis of the inventory is on providing interpersonal and environmentally relevant opportunities to promote musical growth, standard practices and principles of test construction have not been applied in its construction. Similarly, the Observation and Assessment Sheet for Competencies and Interests of children (KOMPIK, available only in German) serves as an observation tool in educational contexts. It provides insights into various developmental areas for children aged 3.5 to 6 years, supporting educational action [56]. For musical development, the questionnaire covers a range of behaviours divided into musical interests (7 items) and competencies (8 items). The questions were formulated in close consultation with educators and experts, and subsequent analyses confirmed the two-factor structure of the musicality questionnaire [57].

An example of a musicality screening aimed at identifying highly gifted students is the checklist that is part of the Munich High Ability Test Battery for Secondary Education (MHBT-S) which is available in German [58]. The musicality checklist includes 11 abilities/feelings that are rated for their presence by a teacher, but no psychometric examination has been conducted [58].

Other measures are ad-hoc questionnaires developed as part of research projects to include a measure of musicality in a research study. These measures have typically not undergone rigorous testing to ensure their reliability and validity and aim to collect specific data on aspects such as musical activities, training, or daily musical interactions [e.g., 59–61]. Consequently, the primary aim is not to formulate a comprehensive measure of musicality, and psychometric standards are often not the primary concern.

A validated tool that assesses music-related behaviours in children under the age of 5 years which is available in English is the Children's Music-Related Behaviour Questionnaire or Child Musical Behaviour Inventory [CMBI; 10]. This parental assessment questionnaire consists of 97 items that assess the frequency of various musical activities such as singing, dancing, and listening to music. There are seven subscales relating to child-initiated musical

behaviour (Attention and Emotion, Vocalisations, Moving, Daily Routines, Requests, Taking Turns, Creativity) and one subscale relating to parent-initiated activities. The subscales showed good reliability (Cronbach´s alpha .77–.97) and structural consistency was confirmed by confirmatory factor analysis [10]. However, with its 97 items, the CMBI is very time-consuming and, so far, it has only been published in English. To give researchers as well as practitioners the possibility to assess musicality both comprehensively and efficiently, there is a need for a screening tool based on empirical evidence and aligned with stakeholder views regarding the aspects that a broad conception of children's musicality should encompass.

Objective

The primary objective of the present study was to develop a screening tool for assessing individual profiles of general musicality in children aged 3 to 10 years, using questionnaire-based assessments from parents and educators. In the development process, our aim was to keep the screening concise yet grounded in a comprehensive understanding of musicality, while also adhering to rigorous questionnaire development procedures. Our overarching goal is to provide researchers with a tool that facilitates the rapid assessment of musicality, supports the investigation of developmental trajectories, and offers insights into individual variations in musical abilities. While the tool is not designed to provide exhaustive measurement, it can contribute to exploring correlations with other cognitive abilities or environmental influences. In educational settings, the screening can be used by educators to tailor their approaches and ensure that each child can benefit optimally from music education. It can also be used to identify particularly gifted children who may benefit from additional opportunities to further their musical development.

We chose the age group of 3 to 10 years as target age range for the screening for several reasons. Firstly, children under 3 years of age have distinct cognitive, motor, and emotional abilities compared to older children [62–64]. Additionally, research suggests that conceptions of musicality in infants and toddlers differ from those of older children [8]. Secondly, by around the age of 10 to 11, middle to late childhood ends [65], and in many countries children enter secondary school, reading speed has developed considerably, and hence self-assessment becomes more feasible. Therefore, focusing on children between the ages of 3 and 10 years allows us to capture crucial developmental stages while ensuring that the questionnaire remains relevant to a wide age range. The questionnaire has been developed in both English and German to facilitate its use in different countries. It has also been designed to be used by researchers as well as educators, parents, and caregivers, allowing its successful application in a variety of scientific and educational settings.

Study 1: Development of the Child Musicality Screening (CHIMUS)

In the first study, an initial screening questionnaire was created, consisting of a large number of items that were intended to reflect child musicality comprehensively. The goal was to reduce the items according to psychometric criteria and to create a quick-to-administer screening of child musicality in German and English, that could be used by teachers and parents to assess the musicality of 3- to 10-year-old children. For readability, we will use the term "parents" throughout the text to refer to both parents and primary caregivers.

Methods

Participants. The study received ethical approval by the Ethics Council of the Max Planck Society (No. 2017_12), and was undertaken with informed consent of each participant. Participants were recruited via the homepage and social media of the Max Planck Institute for

Empirical Aesthetics as well as by directly contacting schools and kindergartens. In addition, Prolific (www.prolific.com), an online platform where registered volunteers receive a small compensation for their participation in questionnaire studies, was used for recruitment [66]. To be eligible for the study, the person completing the survey had to spend regular time (at least 10 hours per week) with at least one child between 3 and 10 years of age. A total of 1,121 people participated in the survey ($n = 649$ German-speaking and $n = 472$ English-speaking), however 311 were excluded due to having completed less than half of the survey ($n = 278$), reporting filling out the survey for a child outside the age range ($n = 31$), or giving implausible answers concerning the number of children they regularly spend time with ($n = 2$). The final sample consisted of 810 ($n = 517$ German-speaking, $n = 293$ English-speaking) participants ($n = 402$ female, $n = 390$ male, $n = 6$ diverse, $n = 12$ n/a) between 18 and 81 years with a mean age of 32.93 years ($SD = 10.43$). Eight participants did not indicate their age. Six hundred and twenty-five participants knew the child from a private setting, 185 from a professional setting. The ages of the children for whom the survey was completed ranged from 3 to 10 years, with a mean age of 6.57 years ($SD = 2.22$).

For further analysis, we established two age groups: the first comprising children aged 3-6 years ($n = 396$), and the second consisting of children aged 7–10 years ($n = 414$). These age groups were chosen for compatibility with our previous paper [7] and because children in Germany usually complete the transition to secondary school at the age of 11. In addition, we considered this to be an age at which self-report is easy to conduct and may be more informative than parental report.

Materials. The initial item pool was created in English and drew from multiple sources. It was primarily based on the items developed by Buren and colleagues [7], who had already established a broad definition of musicality. Additionally, items were extracted from various questionnaires on children's musicality identified through an extensive literature review. Moreover, free-text responses to a query about additional aspects of children's musicality from Buren et al. (7) were incorporated to develop further items [7]. This comprehensive approach resulted in a list of 242 items that collectively encompassed a wide definition of child musicality.

Item reduction was done in several steps. The decision on which items could be removed was made by consensus between three music psychologists (the authors) and two graduate students working on the project. First, clearly redundant items were removed. The remaining items were first aligned so that they all began with the prefix "The child...". Further reduction was done by checking comprehensibility and relevance and by removing items that were similar in content, while maintaining the broadest possible content coverage. The final set of 57 items was sourced as follows: 38 items from Buren and colleagues along with 5 additional items from their questionnaire's open responses [7], 5 items from Burke [55], 6 items from Mayr and colleagues [67], and 3 items from Heller and Perleth [58,68]. To avoid the acquiescence response bias, inverted versions of the items were created and their wording revised. Those 22 items that were easy to understand despite negative wording were then included in the questionnaire in their inverted form. The length of 57 items was considered appropriate for initial empirical data collection (see S1 File for details).

In line with Buren and colleagues [7], a 5-point Likert scale was employed. Depending on the nature of the items, either a frequency scale (ranging from "rarely/never" to "always") or an agreement scale (ranging from "totally disagree" to "totally agree") was used. Item scores for negatively worded items were inversely coded. The questionnaire was then translated into German through a parallel translation process conducted by two native German speakers. This was followed by back-translation and resolution of discrepancies through consensus among the authors. In addition to the musicality questionnaire, we collected

socio-demographic information about the participant and the child, as well as details regarding the formal relationship between the respondent and the child.

Procedure. Data collection for both the German and English versions was conducted online between May and June 2022 using LimeSurvey [69]. Informed consent was obtained by all participants. A pre-screening ensured that participants were fluent in the language of the questionnaire and regularly interacted with at least one child aged 3 to 10 years. Participants were instructed to think of a single child they knew best and to complete the questionnaire with this child in mind. Then, they responded to the items of the musicality questionnaire along with a demographic questionnaire. In total, the participation took approximately 10-15 minutes. Participants recruited via Prolific received compensation for completing the questionnaire, following a plausibility check.

Statistical analyses. Statistical analyses were performed using RStudio, version 4.4.1 [70] and the packages GPA rotation [71], lavaan [72], psych [73], and semTools [74]. To select the items for the final screening questionnaire, an iterative method was used in which the number of factors to be extracted was determined based on a parallel analysis, consistent with established practices [75–77]. Factors were then extracted using exploratory factor analysis with minimum residuals, guided by iterative parallel analyses that allowed for correlated factors and employing oblimin factor rotation. Items were screened and removed in each iteration based on ambiguous or low factor loadings and low communalities. This analysis was based on the German-speaking sample only. As a final step, we tested for invariance between the German and English questionnaire, and between the two age groups (3 to 6 years and 7 to 10 years).

Results of study 1. For the initial rounds of iterations, we conducted an exploratory factor analysis, with the number of factors determined by parallel analysis with 200 simulated datasets. From the results of this analysis, 32 items that loaded on at least one factor with ≥ .3 and had a communality of ≥ .4 were kept for the next iteration with the same criteria. After the second iteration, there were no further changes. Since 32 items was deemed too long for a short questionnaire, a stricter criterion of factor loading of value ≥ .4 on at least one factor was applied for another iteration, while keeping the required communality still at ≥ .4. After conducting three more parallel analyses and EFAs, no further changes were observed in the data, while the number of items was still at 28. Finally, to enhance the interpretability of the factors, an additional criterion was introduced, whereby items should load maximally at one factor. After six more iterations, a preliminary solution with 19 items on three factors was found. Both the relative (TLI, CFI) and absolute fit indices (RMSEA, SRMR) of this model were in an acceptable to good range (RMSEA = .05, CFI = .96, TLI = .95, SRMR = .04).

To determine a questionnaire that exhibits similar characteristics for both language groups surveyed (German and English), a confirmatory factor analysis (CFA) with invariance tests was conducted for the two subsamples of each language. The fit indices CFI and RMSEA at the level of configural invariance, as well as p-values of χ^2 tests, ΔRMSEA, and ΔCFI, were used as indicators for assessing invariance. The latter three values describe the relationships between values at different levels of invariance with increasingly stringent assumptions [78–80]. The following assumptions regarding the groups for the corresponding levels of invariance apply: (1) for configural invariance, the equality of the factor structure; (2) for metric or weak invariance, the equality of factor loadings; (3) for scalar or strong invariance, the equality of factor loadings and intercepts. Other types of invariance testing (e.g., strict invariance or invariance of latent means) were not deemed necessary or helpful to assess in the context of a confirmatory factor analysis following Little [81]. A widely used criterion for empirical invariance testing is a ΔCFI value of no greater than .01 between subsequent levels of invariance [82]. This benchmark was exceeded for the initial 19-item model across

languages (German and English) at the level of scalar invariance (see Table 1), hence, scalar invariance could not be established.

Therefore, we modified the model by removing further items using several strategies. Factor loadings and item variance homogeneity, assessed by Levene's tests with language as the grouping variable, guided these modifications. Several alternative models (A) were checked: (1) Model A1 involved selecting the four items per factor with the highest factor loadings, (2) Model A2 involved selecting the three items per factor with the highest factor loadings, (3) Model A3 involved selecting items with factor loadings greater than or equal to .7, (4) Model A4 involved selecting items with homogenous variance (Levene's test *p*-values greater than .05), and (5) Model A5 involved selecting the three items per factor with the highest *p*-values, provided they were at least .05. (6) For model A6, only homoscedastic items (according to Levene's test) with a factor loading of at least .5 were selected. This approach aimed to optimize both the robustness of the factor structure and the interpretability of the results. To determine the final model, substantive considerations were integrated to ensure that the derived factors were both interpretable and aligned with the predefined criteria. Model A6 with 9 items was selected as the final model, as it fulfilled these criteria effectively. The factor loadings of the final model are displayed in Table 2, while the results of the invariance tests across languages for the final model are presented in Table 3.

In addition to the different language groups considered in the model selection, the sample also comprised various age groups, including children at different developmental stages. To ensure the model's applicability across different age ranges, it was tested for invariance across the predefined age groups of 3 to 6 years and 7 to 10 years. The final model satisfied the criteria for invariance across these age groups as well (see Table 4).

The final version of the questionnaire was named Child Musicality Screening (CHIMUS) and reveals three distinct factors that capture various dimensions of musicality. The first factor, termed Enthusiasm and Motivation, reflects a child's intrinsic motivation and emotional response to music, highlighting their general excitement and enjoyment in making and integrating music into their daily life. The second factor, Music Perception, assesses a child's perceptual skills, including their sense of rhythm, timing, and auditory discrimination. The third factor, Music Production, identifies difficulties related to music-making and reproduction. It encompasses challenges such as attention issues during music-making, problems with reproducing melodies, and overall difficulties in music production. The final model demonstrated good fit indices (RMSEA = .05, CFI = .98, TLI = .98, SRMR = .03). The factors were moderately to highly correlated with each other ($r^{\text{factor1, factor2}} = .56$, $r^{\text{factor1, factor3}} = .52$, and $r^{\text{factor2, factor3}} = .66$).

While the factor model does not include a general factor, the strong correlations between the subscales indicate that a total score may be used to calculate an overall assessment of a child's musicality. According to Sijtsma and colleagues [83], it is not necessary for all items to load onto a single latent factor to justify the use of a total score. In fact, a sum score can serve as a reliable and valid measure even when multiple dimensions are

Table 1. Test of invariance for the initial model across languages.

Level of invariance	CFI	RMSEA	ΔCFI	ΔRMSEA	χ^2	p(χ^2)
Configural invariance	.95	.06			677.55	
Metric invariance	.95	.06	.00	.00	704.64	.041
Scalar invariance	.93	.07	.02	.01	909.03	<.001

CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, ΔCFI = difference in CFI between the current stage of invariance and the previous stage of invariance, ΔRMSEA = difference in RMSEA between the current stage of invariance and the previous stage of invariance.

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Table 2. Factor loadings of the final model.

	Factor loading		
Item	**Factor 1**	**Factor 2**	**Factor 3**
Das Kind…/The child…			
…hat oft den Wunsch, Musik zu machen.[1] …often has the desire to make music.[1]	**.82**	.01	−.05
…hat große Begeisterung für Musik.[2] …has great enthusiasm for music.[2]	**.76**	.03	.04
…genießt Musikmachen als Teil seines Lebens.[2] …enjoys making music a part of his/her life.[2]	**.79**	.01	.04
…hat ein gutes Gespür für Timing und Rhythmus.[1] …has a good sense of timing and rhythm.[1]	.03	**.86**	−.01
…hat ein Gefühl für den Takt.[1] …has a feeling for the beat.[1]	−.04	**.80**	.01
…hat eine gute Hörfähigkeit, z.B. für Melodien und Rhythmen.[1] …has good hearing ability, e.g., for melodies and rhythms.[1]	.17	**.55**	.10
...hat Schwierigkeiten, Musik zu produzieren oder zu reproduzieren.[2] ...shows difficulties in producing or reproducing music.[2]	.09	−.07	**.82**
...passt beim Musikmachen wenig auf, sodass es nicht merkt, ob es so klingt wie beabsichtigt.[2] ...pays little attention while making music, so he/she does not realize if it sounds as intended.[2]	.03	.10	**.54**
…hat Probleme, Melodien, die es zuvor gehört hat, zu reproduzieren.[2] …has issues reproducing melodies he/she has heard before.[2]	−.11	.12	**.71**

[1]agreement scale,

[2]frequency scale.

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Table 3. Test of invariance for the final model across languages.

Level of invariance	CFI	RMSEA	ΔCFI	ΔRMSEA	χ^2	p(χ^2)
Configural invariance	.98	.05			102.32	
Metric invariance	.98	.05	.00	.00	106.22	.691
Scalar invariance	.97	.06	.01	.01	136.78	<.001

CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, ΔCFI = difference in CFI between the current stage of invariance and the previous stage of invariance, ΔRMSEA = difference in RMSEA between the current stage of invariance and the previous stage of invariance.

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Table 4. Test of invariance for the final model across age groups (3 to 6 years, 7 to 10 years).

Level of invariance	CFI	RMSEA	ΔCFI	ΔRMSEA	χ^2	p(χ^2)
Configural invariance	.99	.04			77.98	
Metric invariance	.99	.03	.00	.01	79.11	.980
Scalar invariance	.99	.04	.00	.01	96.74	.007

CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, ΔCFI = difference in CFI between the current stage of invariance and the previous stage of invariance, ΔRMSEA = difference in RMSEA between the current stage of invariance and the previous stage of invariance.

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present. The Child Musicality Screening thus allows for the use of both subscale scores and an aggregated total score. The total scale exhibited good to very good internal consistency as indicated by Cronbach's α (α = .86, 95% CI [0.85, 0.88]) and by the McDonald's ω_{total} (ω = .90; 95% CI [0.90, 0.96]). The α and ω of the subscales Enthusiasm and Motivation and Music Perception were also high, while the Music Production subscale demonstrated acceptable reliability (see Table 5).

Study 2: Assessing the adequacy and interrater reliability of the Child Musicality Screening

In the second study, the new Child Musicality Screening (CHIMUS) was validated using an independent sample. In addition to replicating the factor structure with a new dataset, the goal was to establish interrater reliability by comparing teacher and parent ratings of the same child. The third goal was to gain initial evidence for convergent and divergent validity.

Methods

Participants. The study received ethical approval by the Ethics Council of the Max Planck Society (No. 2017_12), and was undertaken with informed consent of each participant. Schools and kindergartens in Germany were recruited through email and personal contacts. Once a school or kindergarten had agreed to participate, the parents of children aged 3 to 10 were contacted through these institutions. Although the goal was to obtain assessments from both a parent and a teacher for each child, ratings for a child from only a single source were also included (in order to obtain a sufficiently large sample for the assessment of the factor model). A total of 308 parents participated in the survey (244 female, 56 male, 8 n/a), aged 24 to 59, with a mean age of 39.73 years (*SD* = 5.98), 9 parents did not indicate their age. Correspondingly, 261 assessments were provided by teachers. Of these, 154 assessments were attributed to 13 teachers (each completing between 1 and 16 assessments except one, who completed 31), while the remaining 96 teacher ratings could not be attributed to specific teachers due to missing codes. Similarly, analysis of their demographic data was not possible as the majority of teachers did not provide the required information. All participating institutions were located in Hesse or Hamburg, Germany. The mean age of the children assessed was 6.23 years (*SD* = 2.19). Three parent ratings and 4 teacher ratings were removed from the analysis because less than 50% of the Child Musicality Screening had been completed. Additionally, data from one teacher, comprising 7 assessments, were excluded due to negative correlations with the parent assessments, suggesting a potential misuse of the scale. Thus, the final dataset included 305 parent assessments and 250 teacher assessments, with 247 corresponding ratings.

Materials. The questionnaire was administered in paper format. Two versions of the German version of the CHIMUS were created: one for educational staff, prefixed with "the child", and another for parents, prefixed with "my child". Following the structure of the Child Musicality Screening, a 5-point Likert scale was employed, either as a frequency scale

Table 5. Reliability coefficients of the subscales of the final model.

	CHIMUS Total Scale	Factor 1 Enthusiasm & Motivation	Factor 2 Music Perception	Factor 3 Music Production
α	.86	.82	.82	.73
ω	.90	.83	.83	.75

α = Cronbach´s α [84], **ω** = McDonald's ω_{total} [85].

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(ranging from "Rarely/Never" to "Always") or as an agreement scale (ranging from "Strongly disagree" to "Strongly agree"). Negatively worded items were reverse-coded. Additionally, socio-demographic data were collected, along with information regarding the child's most recent school grade in music (school children only). The German school grades were inversely coded, so that higher scores indicate better performance.

In 117 cases, the questionnaire was administered as part of a larger set of questionnaires, because these children took part in another study. Consequently, their parents also completed the German version of the Music@Home questionnaire [86], the German version of the CBQ in its very short form [87], and an adapted version of the BFI-10 [88]. We used the German version of the Music@Home Preschool questionnaire [86] which comprises 17 items encompassing Parental Beliefs, Child Engagement with Music, Breadth of Musical Exposure and Parent Initiation of Musical Behaviour. The very short form of the CBQ [87] comprises 36 items on the scales Negative Affectivity, Surgency Extraversion, and Effortful Control. The BFI-10 is a brief measure of the Big Five personality traits, consisting of ten items that assess the dimensions Neuroticism, Extraversion, Openness to Experience, Agreeableness and Conscientiousness. It was adapted by the authors of this manuscript in order to be used as a parent questionnaire reporting on the personality of their children.

Procedure. Data collection took place between January and November 2023. Paper questionnaires were distributed to participating schools and kindergartens, which then forwarded them to parents along with an information letter detailing the study and data protection measures. Parents who consented to participate signed the consent form and completed the questionnaires. The educational staff collected the completed forms. For children whose parents had agreed to participate, teachers also signed a consent form and filled out a teacher questionnaire, along with a form about their own demographic data and musical background. The schools or kindergartens then returned all forms to the researchers. Participation in the study took approximately 10–20 minutes. No compensation was provided to participants.

Statistical analyses. Statistical analyses were performed using RStudio, version 4.4.1 [70]. Packages used were lavaan [72], psych [73], and diffcor [89]. First, inverted items were recoded. In a next step, the total score of the CHIMUS was calculated as sum score of all items. In addition, subscale totals were calculated by adding up the values from the respective three items of the subscale. These were only formed if none of these values were missing.

Confirmatory factor analysis (CFA) was applied to assess the factorial validity of the newly developed questionnaire using the new sample. To determine whether the factor structure was consistent between parent and teacher data, analyses were performed separately for both groups. Missing data were handled using Full Information Maximum Likelihood (FIML), allowing the use of all available data without the need for imputation. Internal reliability of the parent and teacher ratings was assessed using Cronbach's alpha and McDonald's omega total. Interrater reliability was evaluated through Pearson correlations.

To gain initial evidence of convergent validity, we performed Pearson correlations between the Child Musicality Screening and school grades as well as the Music@Home questionnaire. For divergent validity, we assessed the CHIMUS's correlation with the Extraversion scale (2 items) from the BFI-10 and the Surgency scale (12 items) from the CBQ. We expected no significant correlations with BFI-10 Extraversion nor with CBQ Surgency, as musicality should not be solely attributable to personality traits related to impulsivity, activity level, or pleasure intensity.

Results of study 2. In order to assess the adequacy of the factor model, a CFA was conducted. The fit indices for parents and educators are presented in Table 6. The analysis revealed that the model fit was slightly better for educators compared to parents. Specifically,

Table 6. Fit indices of the rater groups (parents, educators).

	Parents	Educators	$\Delta_{Parents-Educators}$
χ^2	82.71	66.16	
df	24	24	
RMSEA	.089	.083	0.006
CFI	.949	.973	−0.024
TLI	.924	.959	−0.036
SRMR	.061	.038	0.023

CFI = Comparative Fit Index, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual, TLI = Tucker-Lewis Index

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the educator data demonstrated fit indices that were mostly in the good range, while the indices for parents were generally in the acceptable range. This suggests that the model fits the educator data slightly better than the parent data, according to both relative and absolute fit indices.

Following the CFA, internal consistency was assessed for both groups (see Table 7). The results indicate that the internal consistency of the CHIMUS is high across both educator and parent ratings, with particularly strong reliability observed in the educator group. The Production subscale showed slightly lower, yet still acceptable, reliability.

Interrater correlations of educator and parents were assessed. It reached $r = .46$, $p < .001$, $n = 207$, for the overall scale and $r_{motivation} = .43$, $p < .001$, $n = 231$, $r_{perception} = .36$, $p < .001$, $n = 239$, and $r_{production} = .34$, $p < .001$, $n = 219$ for the subscales. These findings suggest a moderate, but highly significant agreement between educators' and parents' assessments, particularly evident in the overall scale scores.

In addition, we examined the correlation between the CHIMUS and the most recent school grade in music, as reported by the parents. Pearson correlations indicated moderate but significant relationships, with the total scale showing $r = .46$, $p < .001$, $n = 83$, and subscale correlations ranging from .30 to .40 (see Table 8). Further support for convergent validity was obtained by correlating the CHIMUS with the Music@Home scale, which was also completed by the parents. The total score of the CHIMUS showed a strong correlation with the Music@Home General factor ($r = .52$, $p < .001$, $n = 96$), with the highest correlation observed for the Enthusiasm and Motivation subscale (see Table 8).

To assess divergent validity, we evaluated the correlation of the CHIMUS with the Extraversion scale of the BFI-10 and the Surgency scale of the CBQ (very short version). The parent ratings of their child´s musicality did not significantly correlate with their assessment of their child's extraversion ($r = .05$, $p = 601$, $n = 101$) or the reported surgency of the child ($r = .00$, $p = .980$, $n = 61$). Additionally, there was no significant relationship between Extraversion/Surgency and the Enthusiasm and Motivation subscale, indicating

Table 7. Internal consistency of educator and parent ratings.

	$\alpha_{educators}$	$\alpha_{parents}$	$\omega_{educators}$	$\omega_{parents}$
Total Scale	.95	.86	.95	.91
Motivation Subscale	.90	.81	.90	.82
Perception Subscale	.90	.84	.90	.87
Production Subscale	.82	.78	.83	.78

α = Cronbach's Alpha [84], ω = Omega total [85]

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Table 8. Convergent validity of the Child Musicality Screening with school grades and the Music@Home General factor, and divergent validity with extraversion (BFI-10) and surgency (CBQ).

	School grade	M@H General factor	Extraversion (BFI-10)	Surgency (CBQ)
CHIMUS	.46*** (83)	.52*** (96)	.05 (101)	.00 (61)
Enthusiasm & Motivation	.30** (89)	.55*** (101)	.10 (107)	.07 (64)
Perception	.36*** (87)	.34*** (103)	.01 (110)	.04 (64)
Production	.40*** (84)	.41*** (97)	.02 (103)	−.09 (61)

Pearson correlations (two-tailed). Values in parentheses indicate sample size (*N*). CHIMUS = Child Musicality Screening, M@H = Music@Home, BFI-10 = Big Five Inventory 10, CBQ = Child Behaviour Questionnaire. * = $p < .05$; ** = $p < .01$; *** = $p < .001$. Sample sizes (*N*) vary due to missing data in some variables.

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that enthusiasm for music is not primarily driven by general extraversion, or related qualities like impulsivity, activity level, or pleasure intensity.

Study 3: Validity and test-retest reliability of the Child Musicality Screening

Study 1 and 2 developed and confirmed the adequacy of the item and factor structure of the Child Musicality Screening and examined the interrater reliability of parents and teacher ratings. Initial evidence also pointed towards the validity of the measure. As the factor model had previously only been confirmed for the German version, our aim in Study 3 was to confirm the factor model for both language versions. In addition, we aimed to analyse the convergent validity with further measures as well as the retest reliability.

Methods

Participants. The study received ethical approval by the Ethics Council of the Max Planck Society (No. 2017_12), and was undertaken with informed consent of each participant. Participants for the online study were recruited through the website and database of the Max Planck Institute for Empirical Aesthetics, as well as via personal contacts and Prolific (www.prolific.com). To expand the educator group, 68 German-speaking trainee educators from a dual-track practice-integrated program, alternating between school instruction and childcare workdays, completed a paper version of the questionnaire. Unlike in Study 2, no overlap between educators and parents was planned, as interrater reliability was not a focus of this study. To qualify for the study, individuals needed to spend regular time with a child aged between 3 and 10 years, and be fluent in either German or English. Participants recruited through Prolific received a small incentive after completing the questionnaire and passing the plausibility check.

A total of 707 individuals completed all sections of the survey (384 German-speaking, 323 English-speaking). However, some were excluded for indicating they did not regularly spend time with children or completing the survey for a child outside the specified age range ($n = 21$), completing less than half of the CHIMUS survey ($n = 2$), failing the attention check ($n = 140$), or providing an unassignable participant code ($n = 2$).

The final German-speaking sample consisted of 296 participants (148 female, 148 male) with a mean age of 33.13 years ($SD = 9.87$). 133 of the participants (44.9%) reported residing in the same household as the child. The children for whom the survey was completed had a mean age of 6.25 years ($SD = 2.15$). Regarding professional background, 35 (11.8%) had completed a pedagogical degree, 41 (13.9%) had received pedagogical training and 100 (37.2%) regularly worked professionally with children. In terms of musical background, 9 (3.0%)

participants had a degree in music and 26 (8.8%) had completed professional training in music. Gold-MSI musical training scale values ranged from 7 to 49 ($M = 22.66$, $SD = 10.22$), with 5.5% receiving the minimum score and reporting no musical training.

The final English-speaking sample consisted of 246 participants (160 female, 84 male, 2 diverse) with a mean age of 37.35 years ($SD = 9.43$). Nearly half of the participants (48%, or 118 individuals) reported residing in the same household as the child. The children for whom the survey was completed had a mean age of 6.52 years ($SD = 2.29$). Most participants were UK residents (63.4%), with the remainder from other predominantly Western, English-speaking countries (Canada: 13.8%, Australia: 8.5%, USA: 8.1%, Ireland: 3.3%, New Zealand: 2.8%). Regarding professional background, 62 (25.2%) had completed a pedagogical degree, 35 (14.2%) had received pedagogical training and 110 (44.7%) regularly worked professionally with children. In terms of musical background, 7 participants had a degree in music, while 11 had some professional training in music. Gold-MSI musical training scale values were between 7 and 44 ($M = 20.51$, $SD = 10.63$), with 12.2% receiving the minimum score and thus reporting having no musical training.

Materials. We employed the 9-item CHIMUS in German or English, respectively, as developed in Study 1. With the aim of testing for convergent validity, we included two measures that indirectly or directly assess musicality in children: parents completed the preschool version of the Music@Home questionnaire, while educators and other individuals not living with the child completed the KOMPIK Musical Interests and Competencies scale.

We used the German [86] and English [11] versions of the Music@Home Preschool questionnaire, comprising 17 items encompassing Parental Beliefs, Child Engagement with Music, Breadth of Musical Exposure and Parent Initiation of Musical Behaviour. Both a general factor and subscale scores can be computed. The authors report a Cronbach´s alpha value of .82 for the total scale (subscales between .66 and .79) for the German and .85 (subscales between .66 and .80) for the English version (for more detailed information on psychometric properties, see [11,86]).

For educators and other individuals not residing with the child, we used the KOMPIK Musical Interests and Competencies scale, in its original German version [67], as well as an English version for English-speaking participants. The translation was conducted by the authors of this manuscript and verified by a native English speaker. The KOMPIK Musical Interests and Competencies scale is part of a comprehensive battery for the observation of children aged 3.5 to 6 years that can be used by educational professionals in childcare facilities. The full version of the KOMPIK comprises 158 observation questions assigned to 11 developmental and educational areas, all pertaining to children's skills, interests, and well-being. One of the developmental domains covered by KOMPIK is music. Musical interests and competencies are further subdivided into two different subscales. The Musical Interests subscale gauges interest in or commitment to musical activities encompassing both music reception and active participation. Observation questions within the Musical Competencies subscale primarily pertain to the child's active approach to music, including their ability to produce music and receptive skills such as the ability to distinguish between different volumes and pitches. The authors report an internal consistency of $\alpha = .92$ for the combined scores of the two subscales, indicating a very high level of reliability in measuring the underlying construct [57].

In addition, participants completed a demographic questionnaire. To assess their musicality, we included the Gold-MSI Musical Training subscale in its German [90] or English version [9], respectively.

Procedure. Participants recruited via Prolific first completed a brief screening questionnaire to assess their eligibility for the study. To qualify, participants needed to regularly spend time with at least one child aged between 3 and 10 years and be fluent in either

English or German. Eligible participants were then invited to complete the survey, which included the Child Musicality Screening along with either the Music@Home questionnaire (for parents) or the KOMPIK items (for educators and other raters). Additionally, they responded to the Gold-MSI items, and provided demographic details. A random subsample was invited to retake the Child Musicality Screening two weeks later. This interval was chosen to balance minimising memory effects among raters while ensuring that any significant changes in the child's musicality were unlikely. In total, 111 German-speaking participants (aged 18 to 70, $M = 35.24$, $SD = 9.45$; mean age of the children $M = 6.37$, $SD = 2.08$) and 89 English-speaking participants (aged 19 to 62, $M = 37.16$, $SD = 8.80$; mean age of the children $M = 6.26$, $SD = 2.29$) completed the survey on both occasions.

Statistical analyses. Statistical analyses were performed using SPSS Statistics, version 29.0.1.0 [91] and RStudio, version 4.4.1 [70]. As in previous analyses, we recoded inverted items, calculated subscale values, and determined total scale values by summing the item values. All analyses were done separately for the German and English sample. We employed CFA to examine the factorial validity of the models. Internal reliability for each subscale, as well es for the overall Child Musicality Screening, was assessed using Cronbach's alpha and MacDonald's omega total. Pearson correlations were calculated for the test-retest reliability analysis. We also performed correlational analyses to evaluate the convergent validity of our instrument with the Music@Home and the KOMPIK Musical Interests and Competencies.

Results of study 3. To assess the adequacy of the factor model, confirmatory fit indices were calculated and are presented in Table 9. The fit indices for the German data fall within the acceptable to good range, while the English data demonstrates a very good fit to the model.

Table 10 presents the internal reliability estimates for the Child Musicality Screening in both its German and English versions, as indicated by Cronbach's alpha and MacDonald's omega total. Overall, the tool exhibits moderate to very good internal consistency, with consistently better results observed in the English version. The Production subscale in the German version showed the lowest reliability, while in the English version, although still acceptable, it was also lower than that of the other subscales. The test-retest reliability for the total scale was very high for both language versions (.88 for German and .86 for English, both with p-values < .001). Most subscales also showed very high test-retest correlations, though the Production subscale in the English version had a good, but somewhat lower, test-retest correlation (see Table 10 for details).

As shown in Table 11, convergent validity analysis revealed moderate to strong correlations between the CHIMUS and the general factor of the M@H questionnaire, as well as very strong correlations to the total scale of the KOMPIK. These results underscore the CHIMUS as a robust measure of musicality that aligns well with established instruments. Notably, as predicted, the correlations with the KOMPIK were generally stronger than those with the M@H, since the M@H scale primarily captures the musical home environment rather than focusing specifically on child musicality. Both the German and English versions of the CHIMUS questionnaire demonstrated significant correlations with various subscales of the M@H and

Table 9. Confirmatory factor analysis for the English and German version of the Child Musicality Screening.

Models	χ^2	df	RMSEA	CFI	TLI	SRMR
CHIMUS German	60.40	24	.072	.956	.934	.046
CHIMUS English	35.73	24	.045	.987	.981	.037

RMSEA = Root Mean Square Error of Approximation, CFI = Comparative Fit Index, TLI = Tucker-Lewis Index, SRMR = Standardized Root Mean Square Residual.

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Table 10. Estimates of internal reliability (Cronbach's alpha, MacDonald's omega total) and test-retest correlations for the general factor and subscales of the German and English version of the Child Musicality Screening.

	α	*ωtot*	test-retest
CHIMUS German Total Scale	.80	.87	.88***
Enthusiasm & Motivation	.79	.80	.81***
Perception	.81	.81	.72***
Production	.65	.69	.76***
CHIMUS English Total Scale	.84	.90	.86 ***
Enthusiasm & Motivation	.82	.83	.81***
Perception	.85	.85	.85***
Production	.73	.75	.66***

α = Cronbach's Alpha [84], ω_{tot} = Omega total [85], test-retest = Pearson correlation (2-tailed), *** = $p < .001$.

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Table 11. Convergent validity of the Child Musicality Screening with the Music@Home preschool and the KOMPIK.

	M@H General factor	M@H Parental beliefs	M@H Child engagement with music	M@H Parent initiation of musical behaviour	M@H breadth of musical exposure	KOMPIK Musical interest and competencies total scale	KOMPIK Musical interest	KOMPIK Musical competencies
CHIMUS German	.58*** (132)	.45*** (133)	.60*** (133)	.35*** (132)	.27** (133)	.73*** (148)	.73*** (153)	.57*** (157)
Enthusiasm & Motivation	.66*** (132)	.49*** (133)	.69*** (133)	.44*** (132)	.33*** (133)	.57*** (148)	.75*** (153)	.31*** (157)
Perception	.33*** (132)	.36*** (133)	.32*** (133)	.17* (132)	.11 (133)	.60*** (148)	.52*** (153)	.54*** (157)
Production	.29** (132)	.26** (133)	.30*** (133)	.15 (132)	.13 (133)	.49*** (148)	.40*** (153)	.45*** (157)
CHIMUS English	.41*** (118)	.36*** (118)	.40*** (118)	.19* (118)	.22* (118)	.71*** (128)	.66*** (128)	.62*** (128)
Enthusiasm & Motivation	.49*** (118)	.35*** (118)	.50*** (118)	.36*** (118)	.21* (118)	.64*** (128)	.72*** (128)	.47*** (128)
Perception	.26** (118)	.33*** (118)	.19* (118)	.03 (118)	.18 (118)	.64*** (128)	.53*** (128)	.60*** (128)
Production	.18 (118)	.14 (118)	.23* (118)	.05 (118)	.11 (118)	.39*** (128)	.30*** (128	.38*** (128)

Pearson correlations (two-tailed). Values in parentheses indicate sample size (*N*). CHIMUS = Child Musicality Screening, M@H = Music@Home, Parent init. of mus. behaviour = Parent initiation of musical behaviour, CBQ = Child Behaviour Questionnaire. * = $p < .05$; ** = $p < .01$; *** = $p < .001$. Sample sizes (*N*) vary due to missing data in some variables.

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the KOMPIK, further establishing its convergent validity. The Enthusiasm and Motivation subscale, in particular, showed strong correlations with the M@H Child Engagement with Music subscale and very strong correlations with the KOMPIK Musical Interest subscale, especially in the German version, where these relationships appeared more pronounced. The correlations align with expectations, with higher values observed for conceptually closer subscales (e.g., CHIMUS Enthusiasm & Motivation with M@H Child Engagement with Music) and lower values for more distinct subscales (e.g., CHIMUS Production with M@H Parental Beliefs). These findings suggest that the Child Musicality Screening effectively captures a broad range of musical behaviours and competencies in children, with the German version showing slightly stronger alignment with established instruments like the M@H and the KOMPIK.

Discussion

The aim of the present paper was to develop and evaluate a short screening questionnaire to assess individual profiles of general musicality in children aged 3 to 10 years. Building on

previous research into conceptions of musicality [7,51], the instrument was designed to cover a wide range of musical behaviours and abilities, reflecting the multifaceted nature of musicality in children. In addition, we aimed to make the instrument available in English and German to increase its accessibility and facilitate comparability in future studies.

To this end, we conducted three studies. In Study 1, an initial pool of items was condensed on the basis of factor analysis and invariance tests for languages and age. The result of Study 1 was the 9-item version of the questionnaire, which we called the Child Musicality Screening. In Study 2, we obtained preliminary evidence of the reliability and validity of the screening in a separate German-speaking sample. To this end, we assessed a parent and a teacher rating for each child. In Study 3, we established retest reliability and conducted more detailed analyses of convergent validity for both the German and the English versions.

Our results indicate that, according to ratings by parents and educators, children's musicality is best characterised by a three-factor model. The model showed scalar invariance for younger and older children and for both language versions. The factors were substantially correlated and corresponded to the dimensions Enthusiasm and Motivation for music, Music Perception, and Music Production.

Enthusiasm and motivation

The factor Enthusiasm and Motivation captures a child's intrinsic motivation and emotional engagement with music, their overall excitement and enjoyment in creating and incorporating music into their everyday activities. Although prior research highlights enthusiasm and motivation as crucial elements of both adult [5,44,51] and child musicality [7,8], these dimensions are rarely included in musicality assessments, hindering the understanding of how emotional engagement influences musical development. Motivation for music-making emerges from complex interactions between individuals and their environment [92]. While research on the heritability of musical sensibility suggest that genetic factors may lay a foundation for musical interest and commitment [93], early musical experiences [44,94,95], the quality of music education [96], and self-efficacy are also critical in shaping motivation and interest. These factors influence self-perception of musical competence and foster ongoing engagement with music [92]. Enjoyment and intrinsic motivation derived from positive musical experiences are essential for supporting sustained engagement and progress in both informal and formal music learning [92,97]. Incorporating these often-overlooked emotional and motivational dimensions into musicality assessments is essential for gaining a more comprehensive understanding of musical development.

The Enthusiasm and Motivation factor exhibited excellent internal consistency among educators and good reliability for parent ratings. It showed comparably high internal consistency in both the German and English versions of the scale. Additionally, the Enthusiasm and Motivation scale also had the highest interrater correlation between parents and educators (.43), making it the factor on which parents and educators were most in agreement. Test-retest reliability over a two-week interval was high, demonstrating that this factor can be measured reliably. Assessing Enthusiasm and Motivation through this subscale could provide valuable insights into its role in musical development and help to determine whether the criticism that motivation is short-lived [98] holds true.

In terms of convergent validity, the correlation between school grades in music and the Enthusiasm and Motivation factor was somewhat less pronounced, possibly indicating that grades may reflect learning outcomes rather than a child's motivation to engage in music. As expected, the Enthusiasm and Motivation scale showed the strongest correlations with measures of children's engagement and interest in music. It was highly correlated with the

KOMPIK Musical Interest scale, but only moderately to the KOMPIK Musical Competencies scale. Similarly, the factor was highly correlated with the Child Engagement scale of the Music@Home questionnaire and moderately correlated with parent-centred scales such as Parental Beliefs and Parent Initiation of Musical Behaviour. These findings indicate that parental beliefs and behaviours are related to child enthusiasm and motivation. Previous research highlighted the importance of parental involvement in musical development, such as providing musical instruments, engaging with the child musically, or enrolling the child in music education programmes, although many parents underestimate the importance of their own musical interactions at home [99]. For instance, active parental involvement during practice sessions has been shown to correlate with children's enjoyment of music and their musical progress [100]. Furthermore, parental influence extends beyond practical involvement to include the values, attitudes, and expectations that parents communicate regarding their children's musical growth [101–103].

Overall, these findings underline the importance of musical enthusiasm and motivation in children's musical development and show that this factor can be reliably measured by our screening questionnaire. Despite its importance, this facet of musicality is often neglected in the assessment of musical ability. However, some researchers have emphasised its importance in identifying musical talent [95] and in achieving high levels of expertise [92,97]. The Enthusiasm and Motivation subscale provides a valuable measure of this essential dimension, allowing for a more comprehensive understanding of children's musicality that goes beyond traditional assessments that focus on perception and production. By considering enthusiasm and motivation as integral components of a child's musicality, new pedagogical approaches could be developed to increase engagement and foster overall musical growth. In research, assessing musical motivation opens up avenues for understanding its impact on long-term musical development.

Music perception

The Music Perception factor reflects traditional views of children's musicality as having a sense of timing and rhythm, a feeling for the beat, and a musical ear. Music perception has long been considered the most prominent candidate for assessing musical talent in children. In fact, since early in the last century, researchers have developed tests that assess music perception skills as indicators of musical ability. Prominent examples of test batteries with an emphasis on musical listening and perception skills include the Seashore Measures of Musical Talent [42], the Measures of Musical Abilities developed by Bentley [43], or the "Gordon tests" [104–108]. More recently developed test batteries include the Profile of Music Perception Skills [PROMS; 109], the Musical Ear Test [110], the Montreal Battery of Evaluation of Musical Abilities [MBEMA; 111], and individual tests that target specific musical skills [e.g., 112–114].

The Music Perception factor not only aligns with the emphasis on music perception in research, but also reflects musical developmental trajectories showing early and continuous growth. From birth, infants demonstrate significant perceptual abilities, related to rhythm [18–20] and pitch perception [21]. As children grow, their perceptual skills become more sophisticated, influenced by cultural exposure and listening experiences [35,115]. Some more complex abilities, like harmony [e.g., 22,116], tempo perception [117], and the recognition of more subtle pitch and sound characteristics develop gradually, reaching reach adult-like proficiency in late childhood or adolescence [23,33]. This underscores the importance of including the perception factor in the Child Musicality Screening to enhance our understanding of music perception development.

The Music Perception factor demonstrated excellent internal consistency in the educator sample and good reliability in the parent ratings (Study 2). In Study 3, this factor also showed good internal consistency across both the German and English samples, reinforcing these findings. The agreement between parents and educators was moderate, which is acceptable given the abstract content of the items (e.g., "the child has a feeling for the beat"), and in comparison to similar studies with low interrater reliabilities between parents and teachers [118–121]. Test-retest reliability was very high, indicating the robustness of the scale. Convergent validity with school grades in music was moderate, suggesting that while the Music Perception factor is related to students' academic performance in music, the correlation is not very pronounced. The Music Perception factor was also only moderately related to the Music@Home scale (weakly related in the English sample), indicating a limited relationship with the musical home environment. However, it showed stronger correlations with the KOMPIK scales, which assess musical interest and competencies and are conceptually closer to the CHIMUS than the Music@Home scale.

Overall, the Music Perception factor effectively captures traditional and essential dimensions of child musicality with reliable measurement properties. Its inclusion in the Child Musicality Screening is essential for assessing musical profiles in children, as music perception undergoes significant development from early to late childhood and serves as a critical foundation for the acquisition of production skills and more complex musical abilities. As such, it is key to understanding and supporting children's musical growth. While further research is needed to explore the convergent validity of the scale with behavioural tests of music perception, the Child Musicality Screening offers a highly time-efficient method for assessing this aspect of musicality. These findings underscore the factor's value in providing a robust assessment of a core element of musicality, which is foundational to understanding and fostering children's musical development.

Music production

The Music Production subscale addresses the challenges children face in producing or reproducing music, such as singing in tune, maintaining a beat, or playing an instrument. Although music production has been shown to be an important component of conceptions of musicality [7,8,51], tests of music production are less common than tests of musical perception. Recent research emphasises the need to include music production in comprehensive musicality assessments [6,7,122,123]. Music production is crucial to assess because its development builds on perceptual skills and progresses throughout childhood [23]. Moreover, music production is evident from very early in development [24,25,29] and children are actively and naturally engaged in musical practices long before formal instruction begins [34,124]. However, certain abilities in singing and rhythm production, only fully develop in late childhood, with some requiring formal training [32]. Thus, music production provides valuable developmental insights, making it an essential component of the Child Musicality Screening. Hence, music production's developmental trajectory offers critical variation to capture, explore, and explain, making it an essential component of the Child Musicality Screening.

The factor Music Production exhibited slightly lower psychometric benchmark values compared to the other two scales, particularly in terms of internal consistency. Specifically, the internal consistency was high for educators and acceptable for parents, whereas the other scales showed good to excellent reliability across both groups of participants. In Study 3, the internal consistency of the German version of the Production scale was just below .70, reflecting marginally acceptable values, while the English version had acceptable reliability (>.70). Interrater correlation was moderate and comparable to the perception scale. Test-retest reliability was

very strong for the German sample but moderate for the English sample. Convergent validity with school grades was established, with the Production scale showing the highest correlation (though still moderate at .40) with music grades compared to the other subscales. This suggests that the ability to produce or reproduce music is more closely related to school grades in music than the other two subscales. The correlation with the Music@Home scale was low for the German version and not significant for the English version, indicating that the Production scale measures a distinct aspect of musical ability. Convergent validity with the KOMPIK scale was moderate for both versions, with slightly higher values for the German version.

The slightly lower or inconsistent values in psychometric criteria could be due to several factors. Notably, the subscale consists exclusively of negatively worded items. This unintentional clustering during factor analysis may have introduced method effects, potentially leading to respondent confusion and impacting the consistency of their responses. Furthermore, the inherent complexity of evaluating music production, particularly in children, could contribute to these issues. Unlike more universally understood constructs like enthusiasm and motivation, music production involves nuanced judgments of various musical features such as key, timing, rhythm, intonation, and creative expression. This complexity might result in increased variability in ratings, particularly when evaluators lack musical training. Existing literature supports the notion that musical performance evaluation is often affected by interrater variability due to its subjective aspects, even in trained observers [e.g., 125,126]. However, unlike positive attributes, which can be abstract and challenging to evaluate, deficits in music production might be more apparent and easier to detect. Rating music production abilities based on difficulties may therefore provide a more accurate and practical method for evaluating skills in creating and reproducing music.

Overall, the Music Production subscale offers valuable insight into a key aspect of children's musicality. Its inclusion in the Child Musicality Screening is essential for understanding the role of music production in musical development and its links to motivation and music perception. The screening captures the critical developmental period when many of the children's production abilities reach levels comparable to those of untrained adults and when some children begin instrumental lessons, marking the start of more structured music production and practice. The subscale showed slightly lower psychometric values than the other factors, possibly due to the negative wording of the items and the inherent complexity of assessing music production. The use of positively formulated items may be a better solution, as it could enhance the clarity and reliability of the responses. Testing this in a follow-up study would be valuable to determine if such changes improve the subscale's psychometric properties. In order to validate the subscale more robustly, future studies should also examine its correlations with behavioural music production tests.

Validity

The development of the Child Musicality Screening involved rigorous testing to ensure both its validity and reliability. Content validity was established in Study 1 through a comprehensive item generation process. A substantial proportion of the items were derived from Buren et al. [7], whose item pool was informed by free-text responses from a diverse group of individuals describing their understanding of musical ability [5], and a subsequent study [51]. This approach reflects musicality as a socially constructed concept. To ensure a comprehensive item pool, additional items were drawn from the literature on musical development. This thorough process ensured that the initial item pool covered key dimensions of child musicality, including rhythmic ability, pitch recognition, musical communication, and musical engagement.

Construct validity was evaluated through exploratory and confirmatory factor analyses conducted in Studies 1–3. The final three-factor structure—comprising Enthusiasm and Motivation

for music, Music Perception, and Music Production—aligned well with existing models, particularly those focused on conceptions of child musicality [7,8]. These studies suggest that while musicality in childhood is multifaceted, it consists of distinct components that differ from those in adults. Interestingly, while previous research on adult musicality [51] identified a greater number of components, our results confirm that a more streamlined structure is sufficient for capturing the essence of children's musical development without oversimplifying it. In line with the identification of Enthusiasm and Motivation as a critical component of children's musicality [7,8], our findings emphasise enthusiasm and motivation as a central element of children's musicality, as evidenced by this being one of three core factors. The separation of Music Perception and Music Production as distinct but interrelated factors further aligns with previous studies on child musicality, which also recognise these as essential components of musical abilities [though combined into a single composite component in previous work; 7,8]. However, the components of Musical Communication and Analytical Understanding that were important components in two previous surveys with stakeholders [parents, educators, music teachers; 7,8] did not emerge as distinct factors in our final screening questionnaire. This may be due to the abstract nature of these components, which makes them difficult for non-experts to assess within a short screening tool. In addition, the previous study asked participants about a hypothetical musical child, whereas our study focuses on typical children, suggesting that these qualities may only become more relevant or observable at higher levels of musicality.

Invariance tests confirmed scalar invariance across different age groups and across the German and English versions of the questionnaire, indicating that factor loadings and item intercepts were consistent across age and language groups. This underlines the robustness of the construct and its cross-cultural applicability in modern Western contexts.

Criterion validity was assessed in Studies 2 and 3 by examining correlations between the CHIMUS and other measures of musicality. In Study 2, correlations with the reported school grade showed a moderate correlation with the CHIMUS Total scale. The German version of the CHIMUS showed a strong correlation with the Music@Home scale in Study 2, which was replicated in Study 3 with an independent sample of participants. The English version of the CHIMUS showed a more moderate correlation with the Music@Home General factor. Very strong correlations were also observed between the CHIMUS and KOMPIK total scales for the German and English versions. At the subscale level, conceptually more similar subscales (e.g., CHIMUS Enthusiasm and Motivation and M@H Child Engagement with Music) showed stronger associations than more divergent subscales. These strong associations, especially when replicated with an independent sample, provide robust evidence for the convergent validity of the CHIMUS. Furthermore, divergent validity was found in Study 2, where CHIMUS scores were not significantly related to Extraversion, as assessed by two different personality/temperament inventories (BFI-10 and CBQ).

Reliability

Regarding reliability, the CHIMUS demonstrated generally high internal consistency across all three studies. Cronbach's alpha and Omega total values for the overall scale and each subscale mostly exceeded the commonly accepted threshold of .70, indicating that the items within each factor reliably measure the same underlying construct. Separate analyses of the internal consistency were conducted for parents and educator ratings (Study 2) and for the German and English version (Study 3). In Study 2, the comparison between educators and parents revealed good to excellent reliability for the educator sample, while the internal consistency for the parent sample was in an acceptable to good range. In Study 3, the internal consistency was also generally high, with the exception of the Production subscale, which was slightly below .70 for

the German version and acceptable for the English version. Analyses of internal consistency for the different groups (parents vs. educators) and versions (German vs. English) thus revealed good to excellent reliability in most cases, with educator ratings being particularly consistent, and the English version showing slightly better reliability than the German version in Study 3.

To explore interrater reliability, differences between teacher and educator ratings were analysed to assess consistency across raters. Interrater reliability showed moderate correlations, with the Motivation subscale exhibiting high interrater reliability. While some discrepancies between ratings were anticipated due to potential parental bias—where parents may rate their children more favourably—the correlations were strong enough to confirm the CHIMUS's reliability across different rater groups. This is notable given the typically low interrater reliability found in similar studies [118–121].

Interestingly, the model exhibited better fit parameters when ratings were provided by professionals (teachers/educators) compared to parents. This suggests that the CHIMUS may yield more reliable results when used by individuals with pedagogical expertise, probably due to the more objective perspective of educators and their ability to compare a wider range of children. Despite the careful design, including the use of negatively worded items, there remains the possibility of response bias such as acquiescence or social desirability, particularly in parent-completed questionnaires. Parents may tend to rate their children more positively, particularly in terms of ability, which could affect the accuracy of the ratings and the overall validity of the results. However, this positive bias may be less pronounced in the motivation domain than in other subscales, which may explain the slightly higher interrater reliability compared to the other two subscales. Admitting a lack of motivation in one's own child may be easier for parents than admitting deficits in ability. In addition, motivation may be more readily assessed by non-experts, making it somewhat easier for laypersons to evaluate compared to other aspects of musicality.

Test-retest reliability was assessed in Study 3 over a two-week interval, showing strong stability of the questionnaire scores ($r = .85$). This suggests that the CHIMUS produces consistent results over time, which is crucial for longitudinal studies and repeated assessments.

Limitations and future studies

Although the Child Musicality Screening has demonstrated strong validity and reliability, further research is essential to extend its utility and address some of its limitations. Although the CHIMUS showed good convergent validity with other questionnaires, future studies should aim to increase its external validity by comparing it with standardised tests of music perception and production. In addition, a more detailed analysis of how different raters—such as parents, teachers, and music educators—assess musicality could provide valuable insights. Understanding the variability in ratings between these groups will help to identify potential biases and ensure that the CHIMUS remains effective in different assessment contexts.

Given that the current study primarily involved participants from Western cultural backgrounds, the generalisability of the findings may be limited. The CHIMUS may not fully capture the nuances of musicality in children from non-Western or underrepresented communities. To address this, future research should focus on cross-cultural validation. This would involve adapting the questionnaire for use in non-Western and culturally diverse settings and then assessing its validity and reliability in these contexts. Such efforts would determine whether the construct of musicality is consistent across different cultural backgrounds and highlight any necessary adjustments to the instrument.

The CHIMUS has been validated across two age groups (3 to 6 years and 7 to 10 years), but its applicability to younger children (under 3 years) or older adolescents remains unexplored.

Future studies could investigate whether the CHIMUS, either in its original or a modified form, can effectively assess musicality in toddlers and adolescents. In addition, longitudinal research would be invaluable in understanding how musicality develops over time. By following musical development from early childhood to adolescence, researchers can examine how early musical characteristics influence long-term skills and related outcomes, such as academic achievement and cognitive development.

The CHIMUS provides a broad overview of musicality and its development, offering valuable insights into general aspects of musical ability and its constituent facets. In order to gain a more detailed understanding of specific developmental changes, additional tests or questionnaires may be necessary. Future studies could investigate how supplementary measures could complement the CHIMUS, with the potential to yield a more comprehensive understanding of musical development across various dimensions.

In summary, the Child Musicality Screening provides researchers and educators with a novel, efficient and reliable tool for the systematic assessment of children's musicality, filling a critical gap in the tools available to assess children's musical development. It is based on current conceptualisations of child musicality, has good psychometric properties and can be applied across different stages of childhood, allowing researchers to explore a wide range of questions related to child development. In addition, the screening facilitates the identification of patterns and trajectories of musical growth, supporting more nuanced investigations of the factors that influence musical ability. By aligning with current conceptualisations of musicality and adhering to rigorous psychometric standards, this tool contributes to a more unified framework for assessing musical ability in children. This data-driven approach not only advances research, but also provides practical benefits for educators. The ability to assess individual musical profiles allows for more tailored educational approaches, enabling educators to better support each child's musical development. By understanding how children's musical skills develop over time, educators can tailor their music education support to better meet the need of individual students, leading to more effective teaching strategies and interventions. Additionally, identifying children with exceptional musical abilities can facilitate targeted interventions and enrichment opportunities to further develop their musical aptitude.

Supporting information

S1 File. Initial item list. The initial item list of the questionnaire in both German and English, with original sources.
(PDF)

S2 File. Child Musicality Screening (English version). The final English version of the Child Musicality Screening.
(PDF)

S3 File. Child Musicality Screening (German version). The final German version of the Child Musicality Screening.
(PDF)

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Initial Item List of the Child Musicality Screening

	German Items	English Items	Original Source
1	…hat ein gutes Gespür für Timing und Rhythmus.	…has a good sense of timing and rhythm.	Buren et al., 2021
2	…besteht nicht auf seinem eigenen Willen beim Musizieren und Genießen von Musik.	…does not insist on his/her own will when making and enjoying music.	Buren et al., 2021
3	…genießt es, zu singen, und macht dies oft.	…enjoys singing and does so frequent.	Buren et al., 2021
4	…zeigt kein Interesse daran, Töne in verschiedenen Umgebungen zu erkunden.	…does not seem curious to explore sounds in different environments.	Burke, 2018
5	…ist in der Lage, Unterschiede zwischen verschiedenen Arten von Musik zu hören und zu untersuchen.	…is able to hear, compare and distinguish different types of music.	Buren et al., 2021
6	…kann genau zuhören und passend musikalisch reagieren.	…can listen carefully and react appropriately to music.	Buren et al., 2021
7	…ist in der Lage, Klang, Tonhöhe und Rhythmen zu verinnerlichen.	…is able to internalize sound, pitch and rhythm.	Buren et al., 2021
8	…benutzt keine neutralen Objekte , um damit Musik zu machen.	…doesn't repurpose music-neutral objects into musical instruments.	Buren et al., 2021 open answer
9	…lässt sich nicht vollkommen auf Klänge ein.	…won't let him-/herself become immersed in sounds.	Buren et al., 2021
10	…ist in der Lage, im Takt mit anderen zu musizieren, indem es Zuhören und Klangerzeugung kombiniert.	…is able to play music in time with others by listening and sound production.	Burke, 2018
11	…ist sehr musikalisch.	…is very musical.	Buren et al., 2021
12	…kann beim Singen oder einfachen Musizieren Emotionen ausdrücken, die ein Zuhörer versteht.	…can communicate emotions to a listener when singing and making music.	Buren et al., 2021
13	…hat eine große Affinität zur Musik.	…has a great affinity for music.	Buren et al., 2021
14	…kann Melodien oder Rhythmen erfinden, entweder mit der Stimme, oder einem einfachen Instrument.	…can invent melodies or rhythms, either with his/her voice or a simple instrument.	Buren et al., 2021
15	…stellt keine Verbindung zwischen Musik und Charakteren und Geschichten her.	…does not associate music with characters and stories.	Burke, 2018
16	…hat eine gute Hörfähigkeit, z.B. für Melodien und Rhythmen.	…has good hearing ability, e.g. for melodies and rhythms.	Buren et al., 2021
17	…scheint in Musik, die es hört, die Stimmung oder darin transportierte Gefühle nicht wahrzunehmen.	…does not seem to pick up on emotions conveyed by music.	Buren et al., 2021
18	…hat ein Gefühl für den Takt.	…has a feeling for the beat.	Buren et al., 2021
19	…versucht nicht, sich musikbezogene Objekte wie Instrumente oder Abspielgeräte anzueignen.	…does not seek to aquire music related objects.	Mayr et al., 2012
20	…kann Melodien gut reproduzieren.	…can reproduce melodies well.	Buren et al., 2021
21	…bewegt sich oft nicht synchron zur Musik.	…often moves out of sync with music.	Buren et al., 2021
22	…kann auf die Stimmung einer Melodie reagieren.	…is able to react to the mood of a melody.	Buren et al., 2021
23	…ist sich verschiedener Aspekte von Musik bewusst, so dass man mit ihm über die Instrumente eines Stückes oder die ausgelösten Gefühle sprechen kann.	…is aware of different aspects of music, so you can talk to him/her about the instruments in a piece or the emotions evoked by it.	Heller & Perleth, 2007
24	…ist motiviert, Musik zu machen, sodass es dabei immer versierter wird.	…is motivated to make music, so that he/she becomes more and more skilled.	Buren et al., 2021
25	…empfindet keine Freude daran, Zeit in musikalischen Umgebungen zu verbringen.	…does not enjoy spending time in musical environments.	Buren et al., 2021
26	…schätzt verschiedene Arten von Musik.	…appreciates different kinds of music.	Buren et al., 2021
27	…kann der Struktur der Musik, die es hört, folgen und darüber sprechen.	…can follow the structure of the music he/she listens to, and talk about it.	Buren et al., 2021
28	…hat keine Assoziationen zwischen Musik und Routinen (hat beispielsweise kein "Händewaschlied").	…has no association between music and routines (e.g. does not have a song for washing his/her hands).	Burke, 2018
29	…zeigt kaum Interesse daran, sich an Muster zu erinnern.	…shows little interest in memorising patterns.	Buren et al., 2021
30	…macht keine Musiker:innen oder Sänger:innen nach und imitiert diese nicht.	…does not mimic or imitate musicians or singers.	Mayr et al., 2012
31	…hat oft den Wunsch, Musik zu machen.	…often has the desire to make music.	Buren et al., 2021
32	…kann sich durch Klang selbst ausdrücken.	…can express him-/herself through sound.	Buren et al., 2021
33	…hat Schwierigkeiten, Musik zu produzieren oder zu reproduzieren.	…shows difficulties in producing or reproducing music.	Buren et al., 2021
34	…erfreut sich an der Beschäftigung mit Musik.	…enjoys being occupied in musical activities.	Buren et al., 2021
35	…hat Probleme, Melodien, die es zuvor gehört hat, zu reproduzieren.	…has issues reproducing melodies he/she has heard before.	Heller und Perleth, 2007
36	…hört gerne Musik und kann sie mit Worten und Gesten beschreiben.	…likes listening to music and can describe it with words and gestures.	Buren et al., 2021
37	…zeigt Schwierigkeiten darin, mit einem offenen Geist auf Musik zuzugehen.	…displays challenges in experiencing music with an open mind.	Buren et al., 2021
38	…erkennt keine Komponist:innen oder Sänger:innen wieder.	…does not recognise composers or singers.	Buren et al., 2021 open answer
39	…findet rhythmische Muster in seiner Umgebung.	…finds rythmical patterns in his/her enviroment.	Buren et al., 2021 open answer
40	…passt beim Musikmachen wenig auf, sodass es nicht merkt, ob es so klingt wie beabsichtigt.	…pays little attention while making music, so he/she does not realize if it sounds as intended.	Buren et al., 2021
41	…kontrolliert die Auswahl der Musik, die es hört, indem es angibt, welche Musikaufnahmen es hören möchte.	…controls his/her listening choices by indicating which recorded music he/she wants to listen to.	Burke, 2018
42	…würde sich eher mit Musik ausdrücken als mit anderen Mitteln.	…would rather express him-/herself through music than through other means.	Buren et al., 2021
43	…kann mit anderen durch Musik kommunizieren, indem es musikalische Geräusche macht, zuhört, improvisiert, tanzt und Musik versteht.	…can communicate with others by producing musical sounds, listening, improvising and dancing.	Buren et al., 2021
44	…interessiert sich für Musik.	…is interested in music.	Buren et al., 2021
45	…bringt mehrere Fähigkeiten zusammen: Es hat musikalische Ideen und versucht, sie umzusetzen.	…brings several skills together: Has musical ideas and tries to implement them.	Buren et al., 2021
46	…unterscheidet nicht zwischen verschiedenen Musikinstrumenten.	…does not distinguish between different musical instruments.	Mayr et al., 2012
47	…zeigt wenig Motivation, mit anderen zu musizieren.	…demonstrates little motivation to make music with others.	Mayr et al., 2012
48	…hat Interesse daran, Musikinstrumente zu spielen.	…shows interest in playing a musical instrument.	Buren et al., 2021 open answer
49	…genießt Musikmachen als Teil seines Lebens.	…enjoys making music a part of his/her life.	Buren et al., 2021
50	…hat große Begeisterung für Musik.	…has great enthusiasm for music.	Buren et al., 2021
51	…ist beim Musikmachen kreativ.	…is creative when making music.	Buren et al., 2021
52	…hat Schwierigkeiten damit, Melodien und Tonverläufe zu erkennen.	…has difficulties in recognizing melodies and tone progression.	Mayr et al., 2012
53	…macht gerne spontan Musik oder musikalische Geräusche.	…likes to spontaneously produce music or musical sounds.	Buren et al., 2021
54	…lässt sich leicht ablenken, wenn es mit musikalischen Aktivitäten beschäftigt ist.	…is easily distracted when engaged with musical activities.	Mayr et al., 2012
55	…wendet Kriterien an, um Musik zu bewerten.	…applies criteria to evaluate music.	Buren et al., 2021
56	…erkennt keine Melodien wieder.	…does not recognise melodies.	Heller & Perleth, 2007
57	…zeigt beim Tanzen zur Musik oder beim eigenen Musizieren, dass es Muster erfassen kann.	…can pick up patterns when dancing or making music.	Buren et al., 2021

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Child Musicality Screening - English Version

MAX PLANCK INSTITUTE
FOR EMPIRICAL AESTHETICS

Please think about the child for each of the following questions and answer each statement on a scale from 1 ("totally disagree" or "never") to 5 ("totally agree" or "always"). There are no right or wrong answers, please select the answer that best applies to the child.

The child…

	1 totally disagree	**2 partly disagree**	**3 neither agree nor disagree**	**4 partly agree**	**5 totally agree**
...has a good sense of timing and rhythm.	☐	☐	☐	☐	☐
...often has the desire to make music.	☐	☐	☐	☐	☐
...has a feeling for the beat.	☐	☐	☐	☐	☐
...has good hearing ability, e.g. for melodies and rhythms.	☐	☐	☐	☐	☐

The child…

	1 never	**2 rarely**	**3 sometimes**	**4 often**	**5 always**
...shows difficulties in producing or reproducing music.	☐	☐	☐	☐	☐
...has great enthusiasm for music.	☐	☐	☐	☐	☐
...pays little attention while making music, so he/she does not realise if it sounds as intended.	☐	☐	☐	☐	☐
...enjoys making music as part of his/her life.	☐	☐	☐	☐	☐
...has issues reproducing melodies he/she has heard before.	☐	☐	☐	☐	☐

Thank you very much for your participation!

Child Musicality Screening - Deutsche Version

MAX-PLANCK-INSTITUT FÜR EMPIRISCHE ÄSTHETIK

Bitte denken Sie bei jeder der folgenden Fragen an das Kind und beantworten Sie jede Aussage auf einer Skala von 1 („stimme überhaupt nicht zu“ bzw. „nie“) bis 5 („stimme voll und ganz zu“ bzw. „immer“). Es gibt keine richtigen oder falschen Antworten, bitte wählen Sie die Antwort aus, die am ehesten auf das Kind zutrifft.

Das Kind…

	1 Stimme überhaupt nicht zu	**2 Stimme nicht zu**	**3 Weder/ noch**	**4 Stimme zu**	**5 Stimme voll und ganz zu**
...hat ein gutes Gespür für Timing und Rhythmus.	☐	☐	☐	☐	☐
...hat oft den Wunsch, Musik zu machen.	☐	☐	☐	☐	☐
...hat ein Gefühl für den Takt.	☐	☐	☐	☐	☐
...hat eine gute Hörfähigkeit, z.B. für Melodien und Rhythmen.	☐	☐	☐	☐	☐

Das Kind…

	1 Nie	**2 Selten**	**3 Manch-mal**	**4 Oft**	**5 Immer**
...hat Schwierigkeiten, Musik zu produzieren oder zu reproduzieren.	☐	☐	☐	☐	☐
...hat große Begeisterung für Musik.	☐	☐	☐	☐	☐
...passt beim Musikmachen wenig auf, sodass es nicht merkt, ob es so klingt wie beabsichtigt.	☐	☐	☐	☐	☐
...genießt Musikmachen als Teil seines Lebens.	☐	☐	☐	☐	☐
...hat Probleme, Melodien, die es zuvor gehört hat, zu reproduzieren.	☐	☐	☐	☐	☐

Herzlichen Dank für Ihre Teilnahme!

8 Publication list

Scientific Papers (peer review)

MacGregor, C., **Buren, V.**, Müllensiefen, D., & Degé, F. (manuscript submitted for publication). Measuring children's motivation for music: a systematic review of existing quantitative tools.

Buren, V., Müllensiefen, D., & Degé, F. (2025). Screening musicality in children: Development and initial validation of a new tool for rapid assessment of musical profiles. *PLOS ONE*. doi.org/10.1371/journal.pone.0317962

Buren, **V.**, Müllensiefen, D., Roeske, T.C., & Degé, F. (2021). What makes babies musical? Conceptions of musicality in infants and toddlers. *Frontiers in Psychology*, 12:736833. doi.org/10.3389/fpsyg.2021.736833

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2021). What makes a child musical? conceptions of musical ability in childhood. *Early Child Development and Care*, 191(12), 1985–2000. doi.org/10.1080/03004430.2020.1866566

Buren, V., Degé, F., & Schwarzer, G. (2021). Active music making facilitates prosocial behaviour in 18-month-old children. *Musicae Scientiae*, 25(4), 449–464. doi.org/10.1177/1029864919892308

Conference Contributions

Buren, V., Schaaf, K., Müllensiefen, D., & Degé, F. (2024). Communication and Creativity: Measuring Musical Expressive Abilities in Children aged 3-6 years [Poster]. *Aesthetic Development Conference*, Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany.

Syring, E.-V., **Buren, V.**, Müllensiefen, D., & Degé, F. (2024). Are there correlations between personality, intelligence and musical communication in kindergarten children? [Poster]. *Aesthetic Development Conference*, Max Planck Institute for Empirical Aesthetics, Frankfurt, Germany.

Buren, V., Schaaf, Katharina, Müllensiefen, D., & Degé, F. (2024). Musicality in Childhood: Assessing Musical Communication Skills in 3- to 6-year-olds [Poster]. 20th Annual *NeuroMusic Conference*, McMaster University, Hamilton, ON, Canada.

Buren, V., Müllensiefen, D., & Degé, F. (2024). Reliabilität und Validität des Child Musicality Screenings zur Erfassung kindlicher Musikalität [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, Munich, Germany.

Buren, V., Müllensiefen, D., Monschau, A., Sava, S., & Degé, F. (2024). The Child Musicality Screening: A New Short Questionnaire to Assess Musicality in 3- to 10-year-olds [Talk]. *Biennial Meeting of the Society for Music Perception and Cognition Conference (SMPC)*, Banff, AB, Canada.

Buren, V., Müllensiefen, D., Monschau, A., Sava, S., & Degé, F. (2024). Development of a short questionnaire assessing child musicality [Poster]. *European Society for the Cognitive Sciences of Music (ESCOM)*, York, UK.

Degé, F., & **Buren, V.** (2024). Musical self-concept formation: The role of growth mindset and academic self-concept [Talk]. *European Society for the Cognitive Sciences of Music (ESCOM)*, York, UK.

Buren, V., Müllensiefen, D., & Degé, F. (2024). The Child Musicality Screening: A new questionnaire to assess musicality in 3- to 10-year-olds [Poster]. *The Neurosciences of Music Conference*, Helsinki, Finland.

Degé, F., **Buren, V.**, & Will, J. (2023). Rhythmic Development in 5- to 8-year-old Children and Adults: The Role of Motor Skills [Poster]. *Annual Neuromusic Conference*, Hamilton, ON, Canada.

Buren, V., Monschau, A., Sava, S., Müllensiefen, D., & Degé, F. (2023). Entwicklung eines Kurzfragebogens zur Erfassung kindlicher Musikalität [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, Hannover, Germany.

Degé, F., **Buren, V.**, & Will, J. (2023). Zusammenhänge zwischen dem musikalischen Selbstkonzept und dem akademischen Selbstkonzept bei 5- bis 7-jährigen Kindern [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, Hannover, Germany.

Buren, V., McGregor, C., Müllensiefen, D., & Degé, F. (2023). Measuring musicality in childhood – Results of a systematic review [Talk]. *International Conference on Music Perception and Cognition (ICMPC)*, Tokyo, Japan.

Buren, V., McGregor, C., Müllensiefen, D., & Degé, F. (2023). Assessment of musical abilities in children - a systematic review [Poster]. *Biennial Meeting of the Society for Research in Child Development (SRCD)*, Salt Lake City, UT, USA.

Buren, V., McGregor, C., Müllensiefen, D., & Degé, F. (2022). Messung musikalischer Fähigkeiten im Kindesalter – ein systematisches Review [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, Würzburg, Germany.

Buren, V., McGregor, C., Müllensiefen, D., & Degé, F. (2022). Assessment of musical abilities in children – a systematic review [Poster]. *Biennial Meeting of the Society for Music Perception and Cognition Conference (SMPC)*, Portland, OR, USA.

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2021). Konzeptionen von kindlicher Musikalität [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, online.

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2021). What makes a Child Musical? [Flash Talk Paper Presentation]. *16th International Conference on Music Perception and Cognition (ICMPC) & 11th triennial conference of the European Society for the Cognitive Sciences of Music (ESCOM)*, online.

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2021). What makes a Child Musical? Conceptions of Musical Ability in Childhood [Poster]. *Biennial Meeting of the Society for Research in Child Development (SRCD)*, online.

Buren, V., Müllensiefen, D., Roeske, T., & Degé, F. (2020). Woran erkennt man ein musikalisches Kind? [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, online.

Degé, F., **Buren, V.**, & Schwarzer, G. (2014). Der Einfluss gemeinsamen Musizierens auf das Hilfeverhalten 18-monatiger Kleinkinder [Poster]. *Jahrestagung der Deutschen Gesellschaft für Musikpsychologie (DGM)*, Erlangen, Germany.