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# Developmental trajectories of pitch-related music skills in children with Williams syndrome

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ABSTRACT

The study of music cognition in Williams syndrome (WS) has resulted in theoretical debates regarding cognitive modularity and development. However, no research has previously investigated the development of music skills in this population. In this study, we used the cross-sectional developmental trajectories approach to assess the development of pitch-related music skills in children with WS compared with typically developing (TD) peers. Thus, we evaluated the role of change over time on pitch-related music skills and the developmental relationships between music skills and different cognitive areas. In the TD children, the pitch-related music skills improved with chronological age and cognitive development. In the children with WS, developmental relationships were only found between several pitch-related music skills and specific cognitive processes. We also found non-systematic relationships between chronological age and the pitch-related music skills, stabilization in the level reached in music when cognitive development was considered, and uneven associations between cognitive and music skills. In addition, the TD and WS groups differed in their patterns of pitch-related music skill development. These results suggest that the development of pitch-related music skills in children with WS is atypical. Our findings stand in contrast with the views that claim innate modularity for music in WS; rather, they are consistent with neuroconstructivist accounts.



**What this paper adds?**

- To our knowledge, this is the first research on the development of music skills in Williams syndrome (WS). The cross-sectional developmental trajectories approach was used to study pitch-related music skills in children with WS. We found a set of atypicalities in the development of such skills. Our results contribute to the theoretical debates regarding music cognition in WS. The findings are consistent with neuroconstructivist accounts and represent further evidence against the nativist views of modularity for music in WS.

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## 1. Introduction

### 1.1. The theoretical relevance of studying Williams syndrome: the case of music cognition

Williams syndrome (WS) is a genetic neurodevelopmental disorder caused by a microdeletion on 7q.1123 (Ewart et al., 1993); WS occurs in only 1:7500 live births (Strømme, Bjørnstad, & Ramstad, 2002). Individuals with WS exhibit intellectual disability and a cognitive profile traditionally described as presenting both relatively good skills in music, language, face processing, and phonological memory and severe difficulties in visuospatial construction, numerical cognition, planning, and problem solving (e.g., Bellugi, Lichtenberger, Jones, Lai, & George, 2000; Levitin et al., 2004; Mervis et al., 2000). Studies of this uneven cognitive profile have contributed to debates regarding cognitive modularity and development. Thus, WS has been used to support both nativist and neuroconstructivist theoretical views in psychology (Karmiloff-Smith, 2009). While the nativist approach claims the existence of innate and independently functioning modules (Pinker, 1991), the neuroconstructivist view argues against innate pre-specification and emphasizes the role of development and the interaction of multiple levels of explanation when considering phenotypical outcomes (Karmiloff-Smith, 1998a; Mareschal et al., 2007).

This divergence can be illustrated in the field of music cognition. The first reports on the topic described individuals with WS as having preserved and exceptional music skills (see Lenhoff, Perales, & Hickok, 2001a; Lenhoff, Perales, & Hickok, 2001b; Levitin & Bellugi, 1998, regarding absolute pitch and rhythm reproduction skills, respectively). From nativist accounts, the fact that individuals with WS seemed to show high music skills despite their intellectual disability was interpreted as evidence that music represents an innate module independent of general cognition (Levitin & Bellugi, 1998; Lenhoff et al., 2001a, 2001b). Along the same lines but more recently, research on auditory processing in WS has led to claim that the syndrome offers evidence in favor of the idea that musical talent represents an innate predisposition (Wengenroth, Blatow, Bendszus, & Schneider, 2010). However, in contrast with this view but in agreement with neuroconstructivist accounts, other research has argued that the music skills of individuals with WS are affected by their cognitive deficits and are therefore impaired (Martínez-Castilla, Sotillo, & Campos, 2011). This would involve that music is not informationally encapsulated, which in turn suggests that music cannot be considered a module in WS. It has also been claimed that music shares processing mechanisms with other cognitive domains in this population (Martínez-Castilla & Sotillo, 2014). Furthermore, it has been suggested that even when individuals with WS reach proficient music skills, these skills may follow developmental pathways different from those observed in typically developing (TD) individuals (Elsabbagh, Cohen, & Karmiloff-Smith, 2010).

### 1.2. The role of pitch in music

In the investigation of music cognition, it is important to consider that pitch structure is a highly relevant factor in musical organization and is crucial to music appreciation (Krumhansl & Shepard, 1979; Trehub, Cohen, Thorpe, & Morrongiello, 1986). Pitch, or tone, is the psychological correlate of the acoustic parameter of frequency (Calvo-Manzano, 1991). Individual pitches may form melodies when sequentially presented or chords when simultaneously presented (Cuddy & Badertscher, 1987; Krumhansl, 2004). Regardless of sequential or simultaneous presentations, the ratios between the pitch frequencies form consonances (simple ratios; e.g., 2:1, the octave interval) and dissonances (complex ratios; e.g., 16:15, the minor second interval) (Hannon & Trainor, 2007; Krumhansl, 2004). In turn, consonance and dissonance discrimination provides a bootstrap into the pitch structure of a musical system, including the Western pitch organization or tonality (Hannon & Trainor, 2007; Trainor, Tsang, & Cheung, 2002). In a broad sense, tonality "involves a hierarchically organized system of pitch relationships" (Cuddy & Badertscher, 1987, p. 609). More specifically, tonality is synonymous with key and defines the musical scale via the establishment of a referential pitch, i.e., the tonic (e.g., C in the key of C major) (Krumhansl, 2004; Krumhansl & Shepard, 1979). The tonic typically sounds at the beginning of a piece of music and, by virtue of its referential role, generally occurs at the end of major phrase boundaries, which provides the listener a sense of appropriate closure (Krumhansl & Kessler, 1982; Schoenberg, 1990). The sense of closure is maximized when the tonic is preceded by the dominant tone (e.g., G in the key of C major) (Schoenberg, 1990). Following the hierarchy of the Western tonal system, the tonic is the most stable tone, whereas the tones outside the scale, also referred to as non-diatonic, are the least stable (Krumhansl & Kessler, 1982; Krumhansl & Shepard, 1979). Both melodies and sequences of chords are arranged according to this hierarchy (Cuddy & Badertscher, 1987; Krumhansl, 2004).

### 1.3. Studies of musical pitch in typically developing individuals: development and relationships with cognitive skills

A clear developmental pattern as to pitch-related music skills has been described in TD individuals (see Hannon & Trainor, 2007, and Stalinski & Schellenberg, 2012 for reviews). Pitch discrimination is a first developmental milestone (Jense & Neff, 1993; Olsho, Schoon, Sakai, Turpin, & Sperduto, 1982). Sensitivity to consonance and dissonance also emerges early in ontogeny (e.g., Trainor et al., 2002). Building on this skill, knowledge of key membership is acquired (Krumhansl & Keil, 1982; Trainor & Trehub, 1994). Later on, sensitivity to harmonic structure (i.e., "the subtle relationships between notes and chords within a particular key"; Corrigall & Trainor, 2010, p. 200) begins to emerge (Cuddy & Badertscher, 1987; Krumhansl & Keil, 1982; Schellenberg, Bigand, Poulin, Garnier, & Stevens, 2005).