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Putting practice into perspective: Child prodigies as evidence of innate talent

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ABSTRACT

The debate over whether exceptional abilities are primarily the product of nature or nurture began centuries ago — and continues to this day. Recently, much of this debate took place within the context of considering the abilities of exceptional musicians. Several of such studies suggested that general intelligence and domain specific skills, both of which fall on the nature side of the spectrum, play a significant role in the development of musical abilities. In this paper, the author demonstrates that those studies which attempted to argue for a purely nurture-driven account of such musical talent, moreover, merely showed that practice has some role to play in the development of talent; they failed to rule out the possibility that factors such as general intelligence and domain specific skills also contribute to the development of exceptional performance abilities. If the evidence generated by studies of exceptional musicians provides a strong basis for believing that nature is the primary driver of exceptional talent, that evidence receives a powerful boost from recent studies of child prodigies. Child prodigies provide a particularly fascinating view on the nature versus nurture debate because of the extremely young age at which the prodigies demonstrate their remarkable abilities, thus, limiting the extent to which their abilities can be solely the result of extreme dedication to practice. Despite this fact, some have still argued that child prodigies' abilities are nurture-driven. Recent research, however, demonstrates that child prodigies' skills are highly dependent on a few features of their cognitive profiles, including elevated general IQs, exceptional working memories, and elevated attention to detail. Other innate characteristics of the child prodigies predict the domain in which the prodigies will excel. Music prodigies, for example, tend to score better with respect to their general IQs, visual spatial abilities, and working memories, than art prodigies. This new research on a group of exceptional – and exceptionally young – performers strongly supports nature as the primary driver of extreme talent.

1. Introduction

The nature versus nurture debate has existed since the beginning of recorded history. As far back as Plato and Aristotle, philosophical thinkers have offered conflicting opinions as to whether nature or nurture is the driving force behind individual differences. While Plato believed that intelligence was an innate ability Aristotle was convinced that the environment was more responsible for the apparent differences in human abilities. In modern times, the debate over nature versus nurture has focused on exceptional performers.

One of the most interesting groups of exceptional achievers is child prodigies. While there is some debate regarding who qualifies as a child prodigy, most agree that child prodigies are individuals who perform at an adult professional level within a culturally relevant domain, either by ten years of age (Feldman, 1986) or before adolescence (McPherson, 2006). Despite the extremely young age at which these individuals reach a professional level of performance, the same practice versus talent debate occurs with respect to these exceptional individuals. Some researchers go so far as to argue that training

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is both necessary and sufficient to produce a child prodigy, while denying the existence of innate talents or gifts altogether (Ericsson, 1996; Howe, Davidson, & Slobada, 1998). Others take the contrary view, positing that innate talent, coupled with practice, is essential for an individual to produce the extreme achievements of child prodigies (Detterman & Ruthsatz, 1999; Feldman, 1986; Feldman & Morelock, 2011; Howard, 2008; Ruthsatz & Detterman, 2003; Ruthsatz & Ruthsatz, submitted for publication; Ruthsatz & Urbach, 2012; Vandervert, 2009; Winner, 1996). Recent studies examining the cognitive profiles of child prodigies produce strong evidence that, while practice is certainly not irrelevant, these child prodigies consistently display several inherent attributes that make it difficult to dismiss the decisive role of innate talent in producing their exceptional early achievements (Ruthsatz & Detterman, 2003; Ruthsatz & Ruthsatz, submitted for publication; Ruthsatz & Urbach, 2012).

This paper will first review and assess the literature discussing the practice versus talent debate as it emerges from studies of exceptional, non-prodigious musicians. It will then turn to the debate as it occurs within studies examining child prodigies, and discuss the striking new evidence emerging from these studies that supports the crucial role innate abilities play in creating child prodigies.

2. Exceptional musicians

Much of our knowledge regarding exceptional achievers has been extrapolated from studies of musicians. Prior research followed the nature vs. nurture debate with studies that investigated either innate variables related to musical achievement or environmental ones exclusively. It is not until a paper by Detterman and Ruthsatz (1999) in which they introduce the Summation Theory that both nature and nurture were measured together to predict exceptional musical performance. The Summation Theory states that all exceptional performance including that of exceptional musical achievement can be predicted best from a regression equation where $Y' = Xg$ (general intelligence) + Xds (domain specific skills) + Xp (practice). The Summation Theory represents a culmination of research in the field of intelligence and musical performance and each variable is briefly reviewed as it relates to findings in the field of musical achievement.

3. General intelligence

General intelligence is a widely studied heritable trait and a meta-analysis of twin studies (Bouchard & McGue, 1981) put the heritability estimate for general intelligence at about 50%. Multiple studies looking only at general intelligence have reported a positive correlation between musical achievement and general intelligence (Lynn & Gault, 1986; Lynn, Wilson, & Gault, 1989). Most convincingly, a review of 65 musical studies found a positive correlation between musical achievement and general intelligence of .35 (Shuter, 1968). Additionally, individuals with mental retardation have delayed musical achievement (DiGiammarino, 1990). However, the existence of musical savants, individuals who have advanced musical skills that coexist with a disability, often autism, support the existence of domain specific skills as a variable that is important to musical achievement.

4. Domain specific skills

Sloboda, Hemmelin, and O'Conner (1985) and Young and Nettlebeck (1995) reported on two separate individuals with savant syndrome. The first musical savant scored a 60 on the performance section of the WAIS. He was interested in music from a very early age and at the age of twenty-one was exceptional in reproducing musical pieces after hearing them. He was able to outperform a professional pianist's musical memory that was used as a comparison for their study. In the second study, Young and Nettlebeck also tested a musical savant for his ability to memorize musical pieces and also for his musical aptitude using the Measures of Musical Ability (Bently, 1966). Again, the savant had an exceptional memory for music and perfect pitch.

The two studies mentioned above fit well with the Summation Theory, both savants had deficits in general intelligence (Xg) but with extreme domain specific skills in music (Xds) coupled with extensive practice. The real disagreement, then, is not whether practice has any role to play in the development of exceptional musical talent; it is whether exceptional abilities can be developed independent of any inherent abilities.

Researchers who advocate this position, and the idea that talent is solely the product of environmental factors, tended to focus either on practice time or on parental involvement. I will discuss two of these studies and then demonstrate how, in each case, the authors failed to discuss evidence that the individuals' innate abilities were also driving differences in performance.

5. Practice

Ericsson, Krampe, and Tesch-Romer (1993) argued that practice alone – independent of any innate ability – is sufficient to produce exceptional musical performance. In a study of violinists, Ericsson et al. concluded that deliberate practice is necessary to become an expert. They stated:

> "Our theoretical framework can also provide a sufficient account of the major facts about the nature and scarcity of exceptional performance. Our account does not depend on scarcity of innate ability (talent)….We attribute the dramatic differences in performance between experts and amateurs–novices to similarly large differences in the recorded amounts of deliberate practice." (p. 392)

In support of this point, the researchers presented data demonstrating that elite musicians reported spending significantly more time practicing by the age of 23 than the other two groups of musicians. Additionally, Ericsson et al. (1993) reported the need for 10 years of deliberate practice to reach exceptional levels of achievement within the music domain.

The authors make a strong argument regarding the importance of practice in building talent among musicians. They fail, however, to rule out the possibility that differences in innate talent were also affecting these musicians' ultimate level of achievement. In fact, a reanalysis of the authors' data demonstrated that those individuals who eventually became elite musicians won significantly more competitions at a very young age than those who eventually became good musicians

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or those who later began training to be music teachers (Ruthsatz, 2000; Ruthsatz, Detterman, Griscom, & Cirullo, 2008). These competitions were won, moreover, long before the musicians had accumulated ten years of deliberate practice (Ruthsatz, 2000; Ruthsatz et al., 2008).

Howe, Davidson, Moore, and Slobada (1995) attempted to establish the critical nature of environmental factors by examining the effect of parental involvement on the musical achievements of their children. The authors theorized that increased levels of parental involvement would be predictive of higher levels of musical achievement. To test their theory, the researchers divided the participants into 5 groups: group 1 consisted of 119 students who had gained admissions to a selective music school through auditioning; group 2 consisted of 30 participants who had applied to the same school but not gained admission; group 3 consisted of 23 participants who inquired about admission but did not apply to the musical institute; group 4 consisted of 27 students who took music at a state school; and group 5 consisted of 58 participants who began lessons and then gave up more than a year before the study began.

The authors claim that the students in group 1 also had significantly more parental involvement in their music lessons and practice sessions than the students in groups 4 and 5, and that it was this difference in parental involvement that resulted in the differences in musical achievement found between group 1 and groups 4 and 5.

While the authors report an interesting finding regarding the extent of parental involvement in group 1 as compared to groups 4 and 5, they do not discuss an equally interesting similarity in parental involvement between groups 1, 2, and 3. The parents for these top three groups of musical performers all reported the exact same levels of involvement for the first three years of practice, (2.6, 2.6, and 2.6). They also report similar levels of involvement for the next three years (2.8, 2.6, and 2.6). Despite nearly identical levels of parental involvement over six years, however, the students in group 1 showed significantly higher levels of musical achievement as measured by The Associated Board and Guildhall School of Music Grades at age 11 than students in groups 2 and 3 (Howe et al., 1995). In the above mentioned 1996 paper, Davidson, Howe, Moore and Sloboda did not report the statistical differences in musical achievement between group 1 and groups 2 and 3, however, an earlier paper based on the same data set did include this information. In this prior paper, Howe et al. (1995), using the same data set as the 1996 paper, reported on early musical behaviors displayed by the same 5 groups of musicians as the above-mentioned paper. The purpose of the 1995 paper was to show that group 1 who had the highest level of musical achievement did not show the earliest musical behavior when compared to the other 4 groups. The evidence in that paper is used to discount the innate talent position. In doing so, the authors found that group 1 had statistically higher levels of musical achievement at age 11 (4.5) when compared to all the other 4 groups (3.1, 3.2, 2.6, and .3) respectively but not the earliest signs of musical ability or interest as reported by their parents. The difference between group 1 and the lower 4 levels of musicians was significant at the .001 level.

To summarize, in both Ericsson et al. (1993) work with elite musicians, and in the study by Davidson, Howe, Moore, and Sloboda (1996), there is evidence of early differences in musical achievement that support innate talent in the musical domain. In the former study, these differences were evident prior to ten years of deliberate practice, and in the latter study, these differences were evident despite nearly identical amounts of parental influence. At the very least, then, these studies fail to rule out the importance of innate abilities in producing exceptional achievement. Recent studies of child prodigies – a group of exceptional performers who, by definition, have had limited practice time – present nearly indisputable evidence of the important role of innate talent in producing exceptional achievements.

6. Child prodigies

Child prodigies provide strong evidence for the existence of innate talent. As an initial matter, they are very young, limiting potential practice time. Recent studies, moreover, have produced compelling evidence that not only is innate talent the primary driver of child prodigies' exceptional abilities, but also that innate differences between prodigies determine the area in which the prodigies will excel.

With respect to prodigious talent generally, Ruthsatz and Detterman (2003) and Ruthsatz and Urbach (2012) argue that the Summation Theory first put forth by Detterman and Ruthsatz (1999), which theorizes that talent is a combination of general intelligence, domain-specific skills, and practice time, can also explain child prodigies' abilities. This research by Ruthsatz and Urbach (2012) on 8 child prodigies in the domains of art, music and math suggests that the innate abilities of child prodigies differ from those of the general population in three clear and systematic ways. First, child prodigies possess an elevated, but not necessarily extraordinary, level of general intelligence. The child prodigies average general intelligence as measured by the Stanford-Binet 5th ed. was 128 ($M = 128$; $SD = 15.31$), with a range of 108–147, while the established mean for the Stanford-Binet 5th ed. is 100 ($M = 100$; $SD = 16$). Second, each of the child prodigies from the 2012 paper by Ruthsatz and Urbach demonstrated an extraordinary working memory. While the average working memory score for the general population is 100, the prodigies achieved a mean score on the Stanford-Binet 5th ed. sub-test of 147, with a range of 138–152. Every prodigy tested had a working memory score at or above the 99th percentile. Third, each of the child prodigies demonstrated an elevated level of attention to detail, as measured by the Autism Spectrum Quotient (AQ) developed by Baron-Cohen, Wheelwright, Skinner, Martin, and Clubley (2001). Attention to detail is one of five categories measured on the AQ with higher scores indicating elevated traits on the autistic spectrum. Each of these abilities – general intelligence, working memory, and attention to detail – is widely acknowledged as at least partially innate.

Other studies have suggested that innate abilities also impact the specific domains in which child prodigies will excel. As Feldman and Morelock (2011 p. 228) suggest, "specific talents for particular kinds of activities (e.g., chess versus visual art) are related to but not determined by general intellectual abilities. It is in the interplay between more general abilities and more specific talents that the child prodigy's area of achievement will crystallize."

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Recent research, moreover, identified the existence of specific inherent traits that were strongly predictive of the domain in which a child prodigy would excel. Ruthsatz and Ruthsatz (submitted for publication) found that child prodigies in the math domain ($M = 140$, $SD = 5.50$) and music domain ($M = 129$, $SD = 11.23$) have higher full scale IQ scores on the Stanford-Binet 5th ed. than art prodigies ($M = 108$, $SD = 6.07$). While child prodigies in the math and music domains had average full scale IQ scores of 140 and 129, respectively, the art prodigies' average IQ score was 108. Despite the small sample size of 16 total child prodigies who completed the full scale Stanford-Binet; 5 in the math domain, 6 in the music domain, and 5 in the art domain, a one-way between subjects ANOVA ($F(2,14) = 17.55$, $p < .001$) demonstrated that this difference is statistically significant at the 0.001 level. A post hoc comparison using Tukey HSD found a statistically significant difference between the art prodigies' full scale IQ ($M = 108$, $SD = 6.06$) when compared to the math prodigies ($M = 140$, $SD = 5.50$) and the musical prodigies ($M = 129$, $SD = 11.23$). There was no significant difference between the full scale IQ scores of the math and the music prodigies.

The math and the music prodigies, moreover, consistently scored higher on the visual spatial subtest of the Stanford-Binet 5th ed. than the art prodigies. While the math and music prodigies had average visual spatial scores of 142 and 116.67, respectively, the art prodigies had an average visual spatial score of 88. A post hoc comparison using the Tukey HSD found that the art prodigies ($M = 88$, $SD = 6.0$) had a deficit in that ability when compared to the math prodigies ($M = 142$, $SD = 10.01$) and the music prodigies ($M = 116.67$, $SD = 24.25$). A one-way between subjects ANOVA $F(2,13) = 13.71$, $p = .001$ was statistically significant at the 0.001 level. The difference between the music prodigies and the math prodigies on the visual spatial subtest was marginally significant. Of further interest was that a one sample t test found that the art prodigies were significantly lower when compared to the standardized norms for the visual spatial subtest on the Stanford-Binet 5th ed. $t(4) = -4.47$, $p = .011$.

Finally, while all of the child prodigies have exceptional working memory scores, the musical prodigies scored significantly higher on this subtest than the art prodigies, achieving average scores of 148 and 132, respectively and reached marginal significance with the math prodigies ($M = 134$, $SD = 15.51$). Interestingly, these cognitive differences found in the subtests on the Stanford-Binet represent which domain specific skills are necessary for the different categories that the child prodigies are likely to excel in; art, music or mathematics. For more information on the different cognitive profiles of child prodigies by domain see Ruthsatz and Ruthsatz (submitted for publication).

Despite this significant evidence of child prodigies' innate abilities, several of the researchers who advocate a nurture-driven account of talent claim that practice or parental involvement can also explain the remarkable abilities of child prodigies. Ericsson (1996) argues that intense early and supervised training, usually led by a parent, is sufficient to produce a child prodigy. He supports his statement with a historical example. Musical prodigy Wolfgang Amadeus Mozart, Ericsson claims, was trained by his father, an eminent music teacher. He believes that other prodigies benefited from similar environmental advantages. Additionally, he states that "In virtually every case it was possible to find documented evidence for adequate teachers living in their home, typically a parent. These teachers instructed the child prodigies and monitored their practice closely from an early age, thus helping them to establish focused and efficient practice" (Ericsson, 1996, p. 32).

Recent and ongoing research provides evidence to the contrary. In a study of 8 child prodigies (Ruthsatz & Urbach, 2012), 4 did not report having access to anyone in their home who could help them develop their exceptional skills in art, music or math. Additionally, in an earlier study by Ruthsatz and Detterman (2003), a musical prodigy achieved such renowned achievements that he was featured on the cover of a national magazine at the age of six, despite not having had any previous music lessons or musical parents.

In their explanation of the unusual early development of child prodigies, Howe et al. (1998) dismiss the early accounts given by parents of their offspring's prodigious abilities as anecdotal and based on memory. Because the researchers involved never witnessed the early indicators of the prodigy's talent, they question the legitimacy of the parent's stories. While previous studies of child prodigies may suffer from these methodological flaws, this does not suffice to dismiss them out of hand. In fact, those studies that these same researchers argue support practice and training as the basis for exceptional achievement similarly rely on historical data, with that data in some cases collected over a decade after the relevant events had taken place (Davidson et al., 1996; Ericsson, 1996; Howe et al., 1995).

As discussed above, there is a significant body of research that suggests at least some innate basis for talent for both non-prodigious musicians and child prodigies. The inherent nature of these exceptional abilities can be even more clearly seen by applying recent research to Howe et al. (1998) own conception of innate ability. According to Howe et al. (1998), if biologically-based talent exists, it must have five properties:(1) It originates in genetically transmitted structures and hence is at least partly innate. (2) Its full effects may not be evident at an early stage, but there will be some advance indications, allowing trained people to identify the presence of talent before exceptional levels of mature performance have been demonstrated. (3) These early indications of talent provide a basis for predicting who is likely to excel. (4) Only a minority are talented, for if all children were, there would be no way to predict or explain differential success. Finally, (5) talents are relatively domain-specific (p. 399–400). Using new data regarding the abilities of child prodigies, I will address each of the criteria that Howe, Davidson and Sloboda claim must be met to demonstrate that child prodigies' abilities are at least partially based on innate talent.

Property 1. *It originates in genetically transmitted structures and hence is at least partly innate.*

New evidence collected from ongoing work with child prodigies (Ruthsatz & Detterman, 2003; Ruthsatz & Ruthsatz, submitted for publication; Ruthsatz & Urbach, 2012) has supported that the cognitive underpinnings for child prodigies have both similarities across domains and differences between domains. As discussed above, child prodigies in the art, music

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and math domains all demonstrate an elevated level of general intelligence as measured by the Stanford-Binet 5th ed. when compared to the general population. As stated above the variability in intelligence is a partially heritable trait (Bouchard & McGue, 1981). Moreover, child prodigies consistently exhibit an extremely elevated score for working memory, and extreme attention to detail as measured by the Autism Spectrum Quotient (AQ).

Both working memory and autistic traits are widely accepted as partly genetic with most researchers stating that autism has an expansive phenotype which is largely genetic (Bailey, Palferman, Heavey, & LeCouteur, 1998; Bolton et al., 1994; Piven, Palmer, Jacobi, Childress, & Arndt, 1997).

Previous research surrounding the three variables, general intelligence, working memory and autistic traits that are consistently reported in child prodigies have been found to have at least partially genetically transmitted underpinnings providing the evidence needed as support for the criteria set forth by Howe et al. (1998).

Property 2. *Its full effects may not be evident at an early stage, but there will be some advance indicators allowing trained people to identify the presence of talent before exceptional levels of mature performance have been demonstrated.*

A recent publication (Howard, 2008) followed the development of eight chess prodigies. The chess domain offers objective measures for early signs of talent by the amount of time the person has competed in chess and the number of chess games played. This systematic and objective scale is not easily found in other domains where prodigies are likely to display talent. The study addresses the issue of early talent predicting later eminence. The eight child prodigies required fewer years to reach master level than other young players not identified as child prodigies, required fewer games to become grandmasters when compared to other chess players, and one of the eight child prodigies in the study became a world champion.

Prodigies in other domains also display advance indications of talent before exceptional levels of mature performance have been demonstrated. One math prodigy studied by Ruthsatz and Urbach (2012) exhibited early indications of his exceptional memory — which, as the research now suggests, is a critical part of a math prodigy's cognitive profile. He began speaking when he was three-months old, produced complete sentences at nine months, and had committed the world atlas to memory by the time he reached 14 months of age. When he was eight, he taught himself college algebra, geometry, and trigonometry in three weeks so that he could enroll in a calculus class at a nearby college. He received an A in that course. When he was thirteen, he published an article in a peer reviewed journal for physics. A musical prodigy tested by Ruthsatz and Urbach (2012) similarly demonstrated advance indications of talent. After becoming obsessed with a musical DVD not long after he turned two, the prodigy began to reproduce the classical pieces on the DVD on the family's piano. His exceptional talent was widely acknowledged, and he began to play with his local symphony when he was six-years old. Another musical prodigy tested by Ruthsatz and Detterman (2003) began to demonstrate the ability to reproduce music he had just heard when he was two-years old. He went on to develop a musical career that was featured on the cover of a national magazine at age 6 and this year at the age of 20 won an award for his musical talent on national television.

Property 3. *Early indications of talent provide a basis for predicting who is likely to excel.*

The musical prodigy who began to reproduce music when he was two-years old began to receive national attention for his musical abilities by the time he was six. By the time he turned twenty, he had received a prestigious national music award. Recently, an art prodigy tested in 2012 sold one of her paintings for six figures this year at the age of 11.

Property 4. *Only a minority are talented.*

Child prodigies are extremely rare. There are not agreed upon estimates at this point in time. However, evidence of their unusual status is the fact that they are featured repeatedly on talk shows and in the news.

Property 5. *Talents are relatively domain-specific.*

Child prodigies are most often found in the domains of art, chess, music and math. Most child prodigies do not display their talents in more than one of these domains. Recent assessments of 16 child prodigies included 5 in the math domain, 5 in the art domain and 6 in the musical domain. Of these prodigies, only three exhibited their talents in more than one domain, making them what Feldman and Morelock (2011) call “omnibus prodigies.”

The specific domain in which a child prodigy will excel, moreover, depends on his or her cognitive profile. As discussed above, child prodigies in the math domain have significantly higher full scale IQs than either child prodigies in art, or music. Child math prodigies have significantly higher scores for the Stanford-Binet 5th ed. subtest of visual spatial skills when compared to either musical prodigies or art prodigies, and art prodigies are dependent on a cognitive deficit on that subtest. Musical prodigies have significantly higher levels of working memory than art prodigies and marginal significance was reported when the music prodigies were compared to the math prodigies' scores for working memory.

7. Conclusions

While Aristotle and Plato may have disagreed about the relative importance of nature and nurture in the creation of exceptional performers, they lacked the benefit of the growing body of research that suggests that both innate abilities and practice time have a role to play in fostering exceptional talent. In the case of non-prodigy musicians, the evidence suggests innate factors, such as general intelligence and domain specific skills, are critical to becoming an elite musician. Those studies that have attempted to argue that such elite musicians are solely the product of environmental factors such as extensive practice time or intensive parental involvement have routinely ignored evidence that their research subjects in fact differed on innate dimensions as well.

If studies of musical ability suggest an important role for innate talent, recent studies of child prodigies demonstrate that

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these innate abilities are not just important but actually essential for prodigies to develop their unique skills. These studies demonstrate that, without exception, child prodigies in various domains possess consistent cognitive profiles that contribute to the early development of their remarkable talents. For example, as discussed above, each of the math prodigies possessed an elevated level of general intelligence, scored above the 99th percentile for working memory, and achieved an elevated score on the visual spatial subtest of the Stanford-Binet 5th ed. As also discussed above, these test scores are generally acknowledged to be based on partially innate characteristics. Using Howe et al. (1998) own framework for assessing whether talent is biologically-based, this new research makes a persuasive case for the importance of innate abilities in creating a child prodigy.

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