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How learning a musical instrument affects the development of skills

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Abstract: Previous research does not teach us much about the role of music for skill development. Learning a musical instrument during childhood may affect educational opportunities by improving cognitive skills, teaching non-cognitive skills or sending positive signals to school teachers. Our study is the first to examine these channels with data from the German Socio-Economic Panel (SOEP). In addition to assessing the duration and intensity of music practice during childhood, the SOEP contains detailed information on parents, which may determine both the decision to follow music lessons and educational outcomes: socio-economic background, personality, involvement in the child's school success and taste for the arts. Using regression-adjusted propensity score matching, we test to which extent these characteristics explain outcome differences between children who have learned a musical instrument for at least 9 years and those who did not. Even after including all of the control variables, cognitive skills of adolescents who followed music lessons during childhood are 0.27 standard deviations above those of their peers. Moreover, these children have better school marks and are more conscientious, agreeable and ambitious. Some of the outcome differences are even larger among children who come from families with lower socio-economic status. The causal effect of learning a musical instrument might be smaller than our estimates due to the potential influence of unobserved characteristics. However, we argue that our strict choice of treatment and control variables may actually lead us to underestimate the true causal effect of learning a musical instrument.

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1 Introduction

A growing number of publicly subsidized projects offering extracurricular music lessons has been initiated in the last decade. These projects aim to give all children – especially those from disadvantaged social backgrounds – the opportunity to learn a musical instrument. For example, the German federal ministry of education has launched its new initiative *Kultur macht stark* (Culture makes strong), which is funded with 50 million euros every year [source]. On the regional level, the state government of North-Rhine-Westphalia annually supports the project *Jedem Kind ein Instrument* (An instrument for every child) with 10 million euros [source]. Originated in Venezuela with the famously known programme *El Sistema*, such projects exist in many countries nowadays. 837 French primary and middle schools run the program *Orchestre à l'Ecole*¹. Similar projects in the United Kingdom are supported in the *Youth Music* network.

What do these projects aim? Their official descriptions sound ambitious. On its website, *Jedem Kind ein Instrument* claims that “Making music is fun and positively influences the child’s development”². With *Kultur macht stark*, the German Federal Ministry of education aims nothing less than “[...] to open new educational opportunities – in particular for disadvantaged children and youth.” They point out that “Creativity, team spirit, effort and the rewarding experience ‘I can do something’ are particularly stimulated by arts, music, theatre and dance”³.

Can learning a musical instrument be the basis of successful social policy initiatives? Can we reduce inequalities in educational opportunity by teaching children from poor families a musical instrument? If music indeed has positive effects on the development of cognitive and non-cognitive abilities, it is important to study them. The importance of cognitive and non-cognitive skills for educational and labor market success has been widely recognized by economists (e.g. Heckman and Kautz 2012, Heckman, Stixrud and Urzua 2006, Heineck and Anger 2010). Moreover, sociologists highlight that cultural capital, or the ability to be familiar with the codes and conducts of a particular social environment, may also have an important influence on success in education and the labor market (Lareau 2011, Lareau and Weininger 2003).

Indeed, numerous studies suggests a strong and persistent link between music and a variety of indicators of educational achievement (Rickard, Bambrick and Gill 2012). Using both qualitative and quantitative methods, they argue that learning a musical instrument is likely to influence academic achievement through three channels. First, learning a musical instrument might influence intelligence directly. Experimental studies by Schellenberg (2004) suggest that instrumental lessons enhance general intelligence by stimulating complex reasoning. Music practice might also influence cognitive skills by crowding other activities (Felfe, Lechner and Steinmayr 2011). Second, music practice may affect non-cognitive skills. In particular, the need to be self-disciplined when learning a musical instrument might increase conscientiousness. Also, music might improve the child’s ambition and internal locus of control, because it teaches to judge own ability and progress (Schumacher 2009). Moreover, children learning a musical instrument might learn social skills by interacting with peers and adults more intensely than in normal school classes (Lareau 2011). Third, even if music practice does not teach any particular skills, educational success might improve thanks to positive signals received by school teachers (Lareau 2011).

Children who learn a musical instrument fundamentally differ from children who do not in terms of observed and unobserved characteristics. Their parents are better educated, earn more, are more likely to participate at cultural events and care more about their child’s school achievement. Hence, it does not come as a surprise that these children are better equipped with cognitive and non-cognitive skills. As Schumacher (2009) points out, studies on the effects of music practice face the difficulty of distinguishing the part of outcome differences which can be considered as a consequence of music from the part which must be attributed to differences in socio-

¹<http://orchestre-ecole.com/>, accessed January 31st, 2013

²<https://www.jedemkind.de/foerdern/home.php>, accessed January 10th, 2013

³<http://www.buendnisse-fuer-bildung.de/content/80.php>, accessed January 10th, 2013

economic background. Strictly speaking, only the experimental studies by Schellenberg (2004) and [... sources of the other experimental studies ...] are able to detect true causal effects. These experimental studies, however, have three shortcomings. They are carried out with a selected group of study participants for whom the results may not be generalizable. Moreover, they examine treatments which are carried out over a short time period. Finally, they focus on brain reactions to music instruction and are therefore unable to detect many important dimensions through which music is likely to affect educational achievement. One of the few other studies studying the effects of extracurricular activities controlling for more than the most basic parental background characteristics was realized by Covay and Carbonaro (2010). Their study, however, is unable to distinguish in detail between the type of activities carried out and therefore rather examines the relation between extracurricular activities in general and cognitive and non-cognitive skills.

With this paper, we aim to make four contributions to the literature. First, we highlight the importance of studying the effects of extracurricular activities such as music practice for the development of skills. While policy makers have recognized the potential of such activities, their implementation is not yet sufficiently accompanied by empirical research investigating the effects of policies such as those mentioned above. Rather than evaluating a particular policy, our contribution to this debate is more general: We study the relation between learning a musical instrument and the development of cognitive and non-cognitive skills.

Second, we are the first to use the German Socio-Economic Panel (SOEP) for examining whether learning a musical instrument is associated with better cognitive and non-cognitive skills. The added value with respect to previous research is twofold. On the one hand, in addition to a detailed assessment of the duration and intensity of music practice during childhood, the SOEP contains many variables which are likely to influence the decision to learn a musical instrument. In particular, we not only observe the typical variables describing the parents' socio-economic status, but also their personality, their involvement in the child's school success as well as their cultural participation. With these variables, we are better able to take selection into account than any previous study on the effects of music. On the other hand, the SOEP is a representative data set. Contrary to previous experimental or qualitative studies, we can therefore obtain generalizable results.

Third, using regression-adjusted propensity score matching, we examine to which extent large outcome differences between children who learn a musical instrument and those who do not can be explained with differences in the abovementioned characteristics. Unsurprisingly, children who learn a musical instrument are not at all comparable to other children, both in their social background characteristics and in their levels of cognitive and non-cognitive skills. However, even after controlling for socio-economic status, the parents' personality, their involvement in the child's school success as well as their cultural participation, large outcome differences remain: Children who learn a musical instrument score 0.27 standard deviations above other children in a cognitive skills test. Moreover, the average mark of children who learn a musical instrument is 0.14 standard deviations higher and their conscientiousness and openness exceed those of other children by a quarter of a standard deviation. Finally, children who learn a musical instrument are 12 percent less likely to watch TV daily and 12 percent more likely to aim at attaining a high school degree and to enroll in university. These results are robust to many different treatment, control and sample specifications.

Fourth, we examine the heterogeneity of the effect of learning a musical instrument in terms of socio-economic status. Given that only few children of families from low socio-economic status learn a musical instrument, we can only distinguish the effect between children from high socio-economic status and children from medium as well as low socio-economic status combined. We find that for some outcomes, the difference between children who learn a musical instrument and those who do not is larger among children from low and medium socio-economic status than among those from high socio-economic status. Differences are larger for children from low and medium socio-economic status when it comes to cognitive skills, the average mark, conscientiousness and optimism with respect to future job success.

Is there a causal effect of learning a musical instrument on cognitive and non-cognitive skills? If the conditional independence assumption is valid, our estimated correlations represent a causal effect of music practice. This is the case if there are no unobserved characteristics, which are uncorrelated with the control variables we use and which determine the decision to learn a musical instrument as well as the development of cognitive and non-cognitive skills. With the estimation method we use, we cannot exclude the possibility that such systematic and unobserved differences exist between children who learn a musical instrument and those who do not.

While our estimation strategy does not allow us to estimate a causal effect, we provide four arguments claiming that the strong association between music practice and higher cognitive and non-cognitive skills may be more than a simple correlation. First, we consider as treated those individuals who have started to learn a musical instrument before the age of 8 and who receive music lessons. We argue that the decision to learn a musical instrument at such a young age is strongly determined by the parents. Controlling for the parents' socio-economic status, their personality, involvement in the child's school success and taste for the arts is therefore likely to capture most of the unobserved characteristics which might violate the conditional independence assumption.

Second, we control for variables which are likely to be strongly correlated with potential unobserved characteristics, but which were measured after the start of music lessons. Hence, these variables might capture part of the true effect of music and lead us to *underestimate* the causal effect. These variables are the parents' involvement in the child's school success – measured at age 17 – and whether the child goes to high school after primary school.

Third, even though we measure outcomes only once at age 17, we can exclude the alternative explanation of reverse causality with a simple test. Subsequently controlling for each of the outcomes does not alter the effect of music on the other outcomes.

Finally, some individuals in the control group have received music lessons for a shorter time period. They might either have started music lessons early and ended them before the age of 17 or have started music lessons later than the age of 8. We are able to show that the effect of music on those individuals is either weakly positive or non-existent. Hence, the existence of partly treated individuals in the control group leads us to underestimate, rather than overestimate the true effect of music on cognitive and non-cognitive skills.

The detailed presentation of our study will start with a review of the previous literature on music education in particular and extra-curricular activities in general. This theoretical part will allow us to identify hypotheses on the potential effects learning a musical instrument may have (Section 2). In Section 3 and 4, we will present the data and method used in this study. Results will be presented in Section 5. Section 6 discusses whether we might interpret the correlations as a causal effect of music practice.

2 Why should learning a musical instrument have an effect?

Numerous studies have found positive correlations between learning a musical instrument and a variety of outcomes related educational achievement (Rickard et al. 2012). While these studies do not detect causal effects, they argue that playing a musical instrument might affect educational success in three ways. First, there might be a direct link between music and intelligence. Second, children who learn a musical instrument might improve their non-cognitive skills. Finally, children may not actually learn any skills when playing music, but still receive an advantage in their educational success. This could result from a positive signal their enrollment in music lessons sends to their teachers. Table 1 summarizes the channels through which learning a musical instrument may affect the development of skills.

Direct effect on cognitive skills. Music education might directly affect intelligence for two reasons. On the one hand, learning a musical instrument requires the brain to engage in complex reasoning (Schellenberg 2009). Therefore, music could directly improve cognitive skills. Numerous

I Improvement of cognitive skills			
	<i>Mechanism</i>	<i>Justification</i>	<i>Possible measures</i>
•	Intelligence	Complex reasoning (Schellenberg 2009)	Cognitive skills
•	Time use	Crowding out of positive or negative activities (Felfe et al. 2011)	Time spent watching TV, reading
II Improvement of non-cognitive skills			
	<i>Mechanism</i>	<i>Justification</i>	<i>Possible measures</i>
•	Self-discipline	Learn self-discipline (Schumacher 2009)	Conscientiousness
•	Self-concept	Judge own ability, success and progress (Schumacher 2009)	Locus of control, ambition
•	Management	Structure learning & time schedule (Lareau 2011)	?
•	Social skills	Interaction with peers & adults (Schumacher 2009, Lareau 2011)	Agreeableness
III Perception and signal			
	<i>Mechanism</i>	<i>Justification</i>	<i>Possible measures</i>
•	Signal	Positive signal for teachers (Lareau 2011)	?
•	Well-being	Belonging to a group (Ormel, Lindenberg, Steverink and Verbrugge 1999, Menninghaus 2011)	?

Table 1 – *Mechanisms through which learning a musical instrument may have an effect*

studies have investigated the link between music and various specific types of intelligence. However, Schellenberg (2009) argues that music presumably affects general intelligence rather than a specific type of intelligence.

In an experimental study, Schellenberg (2004) shows that piano and voice lessons stimulate the intelligence of children. Divided in four groups, the 132 participants of his study receive either piano, voice, theatre or no lessons for a year. By randomly allocating participants to these groups, Schellenberg makes sure that participants are comparable along all observable and unobservable characteristics. Strictly speaking, this study is therefore the only one which is methodologically able to detect a causal effect of music lessons. However, Schellenberg's study participants only receive weekly music lessons over a year and he only measures direct intelligence as an outcome.

On the other hand, learning a musical instrument could influence the development of intelligence or educational achievement through its effect on time use. Two arguments are conceivable. On the one hand, musical practice might enhance school performance, because using free time to play an instrument reduces the time available for potentially harmful activities such as watching TV. On the other hand, time spent learning an instrument is time which is no longer available for learning. Therefore, musical practice could have a negative effect on school performance (Felfe et al. 2011).

Effect on non-cognitive skills. Learning a musical instrument may affect non-cognitive skills in four ways. First, studying a musical instrument requires regular training and thereby forces students to be self-disciplined, persistent and involved (Covay and Carbonaro 2010). As a consequence, learning a musical instrument may improve conscientiousness, one of the five dimensions of the Big Five personality measures. Some psychologists argue that personality is genetically determined and cannot be modified (Pervin, Cervone and John 2005). However, the personality of children can be considered as less stable than that of adults. Heckman and Kautz (2012) discuss

the stability of personality traits and highlight the fact that conscientiousness tends to rise over the life-cycle. For instance, they provide examples of early-childhood interventions which successfully managed to modify personality. In particular, conscientiousness could be improved by programs like the Perry preschool project. Heckman and Kautz (2012) highlight, that these programs did not improve cognitive skills, but still have a beneficial effect, even in the long run. This effect is attained through the program's positive impact on personality.

Second, according to Schumacher (2009), learning a musical instrument improves the ability to judge one's understanding and progress. Contrary to other types of activities or skills, presenting a music piece in front of an audience clearly allows the musician to verify whether she or he is able to correctly interpret the piece. Moreover, music lessons can teach children to judge their ability to learn as well as the modifiability thereof. Schumacher (2009) calls this ability a positive self-concept. Also Covay and Carbonaro (2010) point out that learning a musical instrument teaches a child to handle success and failure. A possible way to measure these potential improvements is to examine the effect of music practice on the internal locus of control. The internal locus of control indicates to which extent someone believes that she or he can influence their own destiny.

While the development of a positive self-concept might support an increase of the internal locus of control, we could also argue that learning a musical instrument is correlated with a lower internal locus of control. Children learning a musical instrument might typically come from families in which parents intervene strongly in their children's time schedules and choice of free-time activities (Lareau 2011). Hence, a potential influence of music on the internal locus of control might be hidden due to a systematically lower internal locus of control among the non-random sample of children who learn a musical instrument.

Contrary to the Big Five personality measures, the locus of control can be considered as modifiable over time. According to Nolte, Weischer, Wilkesmann, Maetzel and Tegetho (1997, p. 11), 20 to 30 percent of respondents changed their answer to the different items on locus of control from one year to the next. The reasons given by Nolte et al. (1997) are: 1) respondents orient themselves at their recent life experiences, 2) respondents interpret the questions in a different way at the two survey times or 3) answer are rather given randomly.

Third, learning a musical instrument can teach children to better structure their learning process (Schumacher 2009). Speaking about middle-class children who have to manage multiple activities organized by their parents, Lareau (2011) highlights the ability to manage one's schedule as well as schedule conflicts.

Fourth, students learning a musical instrument interact with fellow students and teachers. Most of the times, these interactions considerably differ from usual classroom interactions. If the student takes music lessons, she or he will be face to face with a teacher and no or only few other students. Such an exclusive relation with as well as attention from a person of authority teaches the child how to interact with adults and within a certain environment (Lareau 2011). Moreover, if children play their musical instrument in a group – for example a youth orchestra – they will interact with fellow students. On the one hand, they have to learn to take over someone else's perspective, they have to put their own interests back for the benefit of the common goal. With other words, they have to learn to see their fellow students as partners rather than competitors (Schumacher 2009). On the other hand, in particular in music projects proposing access to music education for all, children playing in a group learn to interact with fellow students coming from various social backgrounds (Covay and Carbonaro 2010). In addition to concrete social skills, such interactions with peers and adults teach children the cultural capital they need to interact in a variety of settings. An imperfect way to measure the effect of learning a musical instrument on social skills is to examine the effect on agreeableness, another dimension of the Big Five personality measures.

The study by Covay and Carbonaro (2010) aims to test the causal effect of music practice and other extracurricular activities on the development of non-cognitive skills. Using a rich set of control variables, they examine the effect of extracurricular activities on non-cognitive skills and find

positive effects. However, their data does not allow them to properly distinguish between the different types of activities. Moreover, the abovementioned experimental study by Schellenberg (2004) examines whether music lessons have a positive impact on social skills and finds no effect. However, as stated above, study participants only received piano or vocal lessons for a year and might therefore not have had the time to develop measurable improvements in social skills.

Perception and signal. Learning a musical instrument may not teach any skills to children and still have a positive effect on their educational or labor market achievement. The reason is twofold. First, learning a musical instrument may send a positive signal to school teachers or potential employers. Due to the knowledge about the students' musical free-time activities, school teachers may think that the student is more competent than she or he actually is and reward this perceived competence with a better mark than actually appropriate. Indeed, in her qualitative study with children from different social backgrounds, Lareau (2011) reports that teachers listen more carefully to children talking about their organized free-time activities than to children talking about an unofficial game they played with neighboring children on the street.

As a consequence of learning a musical instrument, the signal effect may also play a role at the entry into the labor market. Rivera (2011) discusses the role of education and extracurricular activities in job application procedures of elite employers. In addition to being perceived of having superior social skills, Rivera (2011) states that having been enrolled in extracurricular activities makes potential employers believe that the candidate is more interesting than a candidate without interests beyond work. Such a candidate thus is believed to be a more pleasant colleague. Moreover, people with extracurricular activities are likely to have superior time management skills and a higher work ethic.

In order to measure this signalling effect, one would need a good measure of discrimination. Andersen and Hansen (2012) gives some hints for how to identify such a measure. They point out that the extent of the signal effect depends on the type of school subject. For talent subjects such as language classes, the signal effect should play a stronger role in the determination of the evaluation than in subjects which require hard work such as mathematics. Moreover, the signal effect depends on the type of evaluation and is likely to be more present in oral than in written examinations. Finally, the signal effect depends on the educational level [... explain ...].

In addition to physical well-being, Ormel et al. (1999) consider social well-being as one dimension human beings aim to maximize. Social well-being consists of three facets: 1) Status, 2) Behavioral confirmation and 3) Affection. Music education could play a role in the determination of status. According to Ormel et al. (1999), the status is the relative ranking compared to other people. It is attained, for example, through "occupation, life style, [and] excellence in sports" (Ormel et al. 1999, p. 67). Playing a musical instrument could therefore contribute to attaining a higher status. Contrary to the previously discussed external signal, which signals higher skills to other people, playing a musical instrument signals affiliation to a particular social group and thereby raises the well-being of the individual himself.

Indeed, Menninghaus (2011) relates participation in the arts to the costly signal theory. He states that the possession of artistic objects or the engagement in artistic activities are used by people from a certain social status to signal their affiliation to that social group. Given that the arts are costly, they can be sure that their possession is an effective means to distinguish oneself from individuals with lower social status. Menninghaus (2011) highlights parallels between such a costly signal and Darwin's interpretation of the role of the arts.

Both the role of music in sending positive signals to school teachers and in determining social well-being through status attainment rely on complex outcome variables which are difficult to measure. To our knowledge, no study has managed to show these effects so far.

The aim of the abovementioned music education projects is to improve educational opportunities in particular for children from disadvantaged social backgrounds. However, most of these

projects affect all students, even those from advantaged social backgrounds who would have learned a musical instrument anyway. Therefore, an average treatment effect of music education does not tell us whether music education can affect all students, in particular those who are meant to be affected. Hence, the question arises whether the effect of learning a musical instrument varies according to socio-economic status.

From a theoretical perspective, contradicting hypotheses exist with regards to differential effects of music education for children from families with low and high socio-economic status. The argument derived from Bourdieu's (1986) cultural reproduction model states that learning a musical instrument benefits higher socio-economic status children more than those from low socio-economic status because their parents will put more effort into finding high-quality activities and contribute to making such activities more effective. On the contrary, the argument derived from DiMaggio's (1982) cultural mobility model states that children from low socioeconomic backgrounds benefit more from extracurricular activities because they have a higher potential to increase their commitment to school.

Are the potential effects on the development of cognitive and non-cognitive skills specific to music or could they be achieved with any other activity as well? Some mechanisms can be seen as such, in particular the hypotheses relating music to cognitive skill development due to particular reactions of the brain. Also, one could argue that the positive self-concept – the ability to judge one's ability and progress – is particularly stimulated by music education. Further mechanisms could be related to music education given that they need a long time to be trained. Music is usually carried out over a long period. Hence, mechanisms or skills which need a long time to develop might be trained more with music than with other activities, such as self-discipline, time management, improvement of intelligence and the interaction with peers. However, if other activities are carried out over a long period, these activities could result in the development of such skills too. Finally, the improvement of skills due to changes in time use and time management are not specific to music. Whether the signalling effect could also be achieved with alternative activities depends on the school teacher's opinion on the respective activity.

3 Data: The German Socio-Economic Panel Study

The German Socio-Economic Panel study (SOEP) is currently the best available data to study the effects learning a musical instrument. First, it contains a detailed assessment of the intensity and duration of music activities during youth. Second, the SOEP measures a large variety of outcomes such as school results, cognitive skills, personality, time use and ambition. Third, given that it is a household rather than an individual survey, using the SOEP allows us to directly observe numerous parental and household background characteristics. In particular, we are able to measure the parents' socio-economic background, personality, involvement in the child's school success as well as taste for the arts. Finally, new developments of the SOEP data will allow us to study the long-term effects of music as well as to improve our analysis in the future. The detailed and newly collected data on children already allows us to investigate some of the shortcomings of our main estimation, as discussed in Section 6.

First, it contains a detailed assessment of musical practice during youth. At the age of 17, young adults answer the following five questions [cite SOEP Youth Questionnaire]:

1. Do you play a musical instrument or pursue singing seriously? (Yes or no)
If the answer is yes, the following further questions are asked:
2. What type of music do you make? (Classical, Pop/Rock/etc or Folk music)
3. Do you do this alone or in some sort of group? (Alone/with teacher, in an orchestra/choir, in a band or in another type of group)
4. How old were you when you started? (Age)

5. Do you take or have you ever taken music lessons outside of school? (Yes or no)

With these answers, it is possible to construct a variety of treatment indicators. In addition to the youth questionnaire, the SOEP's household questionnaire biannually asks parents to provide information on their children's free-time activities since 2006. With this data, it will be possible to examine more closely the duration of music lessons. However, for the moment, we have a very limited number of observations.

The only other extracurricular activity which is assessed in similar detail in the SOEP youth questionnaire is sports. This will allow us to test the robustness of our effects with respect to the alternative of doing sports regularly. Information on further activities is very limited and can therefore not be used as further robustness checks.

In addition to childhood information, the SOEP Youth Questionnaire examines the young adult's current skills and opinions and contains information on her or his plans about the future. These outcome measures allow us to investigate several of the potential mechanisms of the effect of music education described in Section 2.

Cognitive skills are assessed since 2006. The cognitive skills test consists of three subscores: analogies, figures and mathematics operators. Good verbal knowledge is indicated by high scores for Analogies, where respondents have to identify correct word pairs⁴. To get a good score in Figures, respondents have to identify the correct symbol continuing a given row of symbols. Similarly, the test of Mathematics operators requires individuals to insert operators in incomplete mathematical computations. In order to facilitate the interpretation of cognitive skills, all results were normalized.

In addition to directly testing their cognitive skills, the SOEP Youth Questionnaire asks young adults about the latest school marks they obtained in German, mathematics as well as in their first foreign language. We normalize these marks by school type in order to account for systematic differences between the German lower, medium and higher secondary school⁵.

Furthermore, young adults are asked to indicate how they spend their free-time. Along with some other activities, the SOEP Youth Questionnaire asks them whether they read and watch TV daily, weekly, monthly, less often or never. As a large share of the respondents read and watch TV daily, we coded both activities as binary variables indicating whether the activity is carried out daily or less often. In order to accurately investigate the hypotheses according to which music crowds out good or bad alternative activities, it would be even better to know how many hours a day young adults spend reading and watching TV. Unfortunately, this information is not available to us.

The SOEP Youth Questionnaire investigates various dimensions of personality using simplified, but psychologically validated personality questionnaires. For our study, conscientiousness, openness and agreeableness, three dimensions of the Big Five personality traits (McCrae and Costa 1999) seem particularly interesting. In order to assess the first, respondents have to state to which extent they consider themselves as rigorous, lazy and efficient. Whether someone is agreeable depends on the degree to which they think they are rude, friendly and forgiving. In addition to these two dimensions of the Big Five personality traits, our hypotheses (see Section 2) suggest that learning a musical instrument may increase the internal locus of control. Someone is characterized by a high internal locus of control if she or he agrees that their life depends on oneself, that success results from working hard and that abilities are more important than working hard [cite Rotter 1966]. For all personality traits, average values of the answers to the related questions are used.

In addition to assessing current skills and personality, the SOEP Youth Questionnaire asks young adults about their plans and worries about the future. For this study, we are interested in whether the young adult plans to obtain a high school degree as well as whether she or he is planning to attend university. In addition to their educational plans, all respondents are asked to estimate

⁴Such as *meadow : grass* corresponds to *forest : trees*

⁵Hauptschule, Realschule and Gymnasium

the probability of whether they will find a job in their desired occupation and whether they will be successful in their job. In order to be able to interpret the magnitude of potential treatment effects, we normalize these estimated probabilities.

The SOEP is particularly suited for our research question because it is a household rather than an individual survey and therefore contains rich information of each young adult's family. This is important because the families of children who learn a musical instrument differ strongly from families who do not enroll their children in music education. As described in Section 4, we model the selection into musical practice in order to account for these differences. In addition to being able to control for time-invariant socio-economic characteristics such as parental education and the mother's age at birth, the SOEP's panel structure allows us to take into account the family environment when the child was young. Such time-varying parental background characteristics are monthly household net income, number of siblings, number of rooms per person, proximity to a sports facility and whether the family lives in a rural or urban area. All time-varying variables were measured either when the child was five or when the family first entered the SOEP.

The main advantage of the SOEP compared to other data is that in addition to the standard socio-economic characteristics of the parents, we observe some important variables which are likely to influence the decision to enroll the child into music lessons. These variables are the parents' personality, their involvement in the child's school success as well as the parents' taste for the arts. Personality is measured with the Big Five personality traits conscientiousness, openness, agreeableness, neuroticism and extraversion (McCrae and Costa 1999). Each of these dimensions is assessed with three questions, of which we take the mean. Please refer to the annex for a list of the questions asked. Personality in the SOEP was measured in 2005 and 2009. For each family, we use the earliest available measurement. Moreover, we use the personality of the mother if available and of the father otherwise. The parents' involvement in the child's school success is asked retrospectively at the age of 17 and reported by the adolescent herself in the SOEP Youth Questionnaire. It is measured with eight questions asking to which extent parents were in contact with the child's school. Please refer to the annex for a complete list of the questions asked. The parents' taste for the arts is measured - cultural participation - artistic activities - openness for the arts - mother if available, father otherwise - measured when the child was aged five or at the entry into SOEP

Moreover, we observe whether the child entered a lower or higher secondary school (Hauptschule, Realschule or Gymnasium) after primary school and are able to control for this variable, which is an important predictor of academic success summarizing numerous observed and unobserved characteristics.

A further aim of this paper is to examine the heterogeneity of the effect of learning a musical instrument with respect to differences in socio-economic background. On the one hand, we can distinguish socio-economic background according to characteristics of the parents. As our main specification, we will consider parents who have either a lower secondary school degree (Hauptschule) or a medium school degree (Realschule) as belonging to the low/medium socio-economic status group. For high socio-economic status, we will consider parents with either high school or university degree. Unfortunately it is not possible to further distinguish among children from low socio-economic status, because too few of these children learn a musical instrument. In addition to differences in socio-economic status, we will consider differences in the probability of learning a musical instrument in order to examine the possibility of heterogeneous effects.

If we consider only individuals with no missing values on any treatment or control variable, we obtain a final sample of 2385 observations out of the 3710 who have answered the SOEP Youth Questionnaire. 213 of these are active in music according to our definition, which is that they have learned a musical instrument at least since the age of eight. As Figure 1 indicates, the share of children learning a musical instrument is considerably higher among girls and among children from high socio-economic status.

Table 2 shows that children learning a musical instrument are not at all comparable to those

	<i>No music</i>	<i>Music</i>	<i>Difference/ Std error</i>
<i>Parents' socio-economic status</i>			
Monthly household net income (in Euros)	2444	3578	-1134*** (111)
Mother has university degree	0.18	0.36	-0.18*** (0.03)
Mother only finished 9 years of school	0.31	0.15	0.15*** (0.03)
Mother has no degree	0.19	0.06	0.13*** (0.03)
Mother has vocational degree	0.68	0.65	0.03 (0.03)
Mother has foreign nationality	0.12	0.05	0.07*** (0.02)
The respondent is a girl	0.47	0.66	-0.18*** (0.04)
Oldest child in family	0.49	0.47	0.01 (0.04)
Number of siblings (in SOEP)	1.51	1.53	-0.02 (0.09)
Rooms per person in family home	1.09	1.27	-0.18*** (0.03)
Mother's age at birth	27.44	29.67	-2.23*** (0.36)
<i>Geographic characteristics</i>			
Less than 10 minutes to sports facility	0.43	0.42	0.01 (0.04)
Rural area	0.24	0.17	0.07** (0.03)
East Germany	0.21	0.11	0.10*** (0.03)
<i>Parents' involvement with school</i>			
Parents care strongly about school achievement	0.26	0.29	-0.03 (0.03)
Parents don't support learning	0.24	0.19	0.05 (0.03)
Conflict with parents due to school results	0.57	0.50	0.07* (0.04)
Parents go to parent-teacher meeting	0.74	0.81	-0.07** (0.03)
Parents go to teacher's consultation hours	0.58	0.55	0.03 (0.04)
Parents actively contact school teachers	0.22	0.29	-0.07** (0.03)
Parents engage as parent representatives	0.16	0.31	-0.16*** (0.03)
Parents don't engage with the child's school	0.09	0.07	0.02 (0.02)
<i>Personality of parents</i>			
Conscientiousness (parents)	0.87	0.86	0.02* (0.01)
Extraversion (parents)	0.71	0.71	0.00 (0.01)
Agreeableness (parents)	0.81	0.80	0.01 (0.01)
Openness (parents)	0.65	0.69	-0.04*** (0.01)
Neuroticism (parents)	0.59	0.58	0.02 (0.01)
<i>Parents' taste for the arts</i>			
Mother never attends cultural events	0.42	0.13	0.29*** (0.03)
Mother monthly attends cultural events	0.09	0.25	-0.17*** (0.02)
Mother is never artistically active	0.54	0.23	0.31*** (0.04)
Mother is artistically active monthly	0.20	0.41	-0.21*** (0.03)
Appreciation for art (parents)	0.63	0.72	-0.09*** (0.02)
Number of observations	2385		

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Definition of *Music*: Have music lessons before age 8.

Table 2 – Significant differences between children learning a musical instrument and those who do not

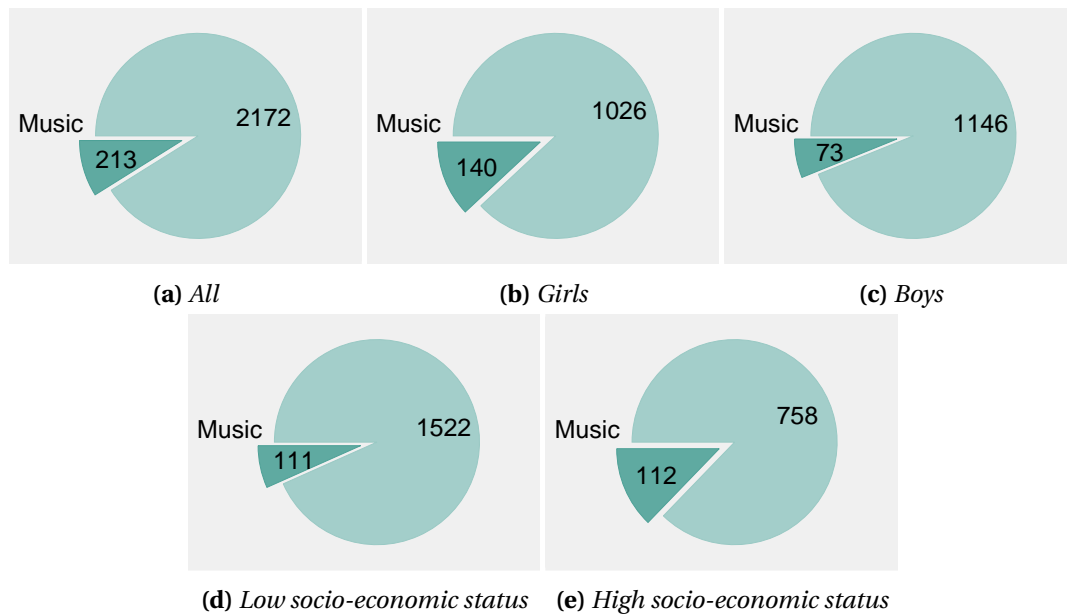


Figure 1 – Share of respondents who have learned a musical instrument since the age of 8 years

who do not. [... Discussion of the table to be added here ...]

New questions recently introduced in the SOEP allow us to address some of the criticism our main analysis will inevitably face. On the one hand, since 2006, every household is questioned bi-annually about the details of all children's free-time activities. Parents have to indicate, whether their child participates in sports, music or arts activities. Moreover, if their child is already in school, parents additionally indicate whether the child participates in school-based workshops, or is engaged in youth centers or children's groups (such as path finders) or aid organizations. While the sample size for these data is still too small to be used as a main sample, these questions will allow us to test the fate of those who are in our control group and therefore rule out some competing or even contradicting explanations.

Since 2003, the SOEP collects detailed information on all children born in SOEP households throughout their childhood. In a few years, this child sample will allow us to be much more precise in our estimates of the effects of learning a musical instrument. For now, these children are too young to be included in our main analysis. However, we can benefit from this additional sample to understand more precisely the selection into music practice. Finally, in a few years the longitudinal nature of the SOEP will allow us to examine the long term outcomes of musical practice using the same sample as in the present study.

4 Method

Obviously, the decision to learn a musical instrument is strongly influenced by parental background. Children who learn a musical instrument typically have more educated parents, who earn more, are more involved in the child's school success and have a strong preference for the arts. Moreover, children learning a musical instrument have significantly higher cognitive and non-cognitive skills. Are these advantages in cognitive and non-cognitive skills simply a consequence of the advantaged social background or is there a positive influence of music practice itself on skill development? In our data, we are not able to observe a random variation in the enrollment into music lessons. Therefore, this paper aims to examine to which extent the strong positive correlation between learning a musical instrument and skills can be explained with family background characteristics.

We use regression-adjusted propensity score matching to account for the non-random decision

to learn a musical instrument. While similar results can be obtained with a simple linear regression model, propensity score matching has three advantages for our purpose. First, it allows us to use a large number of control variables even with a limited sample size given that these control variables are summarized in one variable, the propensity score (Huber, Lechner and Wunsch 2012b). Second, contrary to ordinary least squares we do not need to assume a linear relation between learning a musical instrument as well as all of our control variables and the outcomes we are interested in. Finally, in a setting where children learning a musical instrument are likely to have a strongly different family background than other children, checking the common support will provide us with some hint on the comparability of treatment and control group. Given that our control group is ten times as large as the treatment group, we can find high quality matches for most treatment observations.

Among propensity score estimators, Huber et al. (2012b) conclude that a regression-adjusted kernel matching estimator based on a triangular truncated kernel is the most efficient. Such an estimator is robust if either the selection model is correctly specified or the bias-reducing regression model contains all relevant variables⁶ (Huber et al. 2012a).

We implement our estimator in the following way. First, for each individual of our sample we estimate the probability of learning a musical instrument with a probit model. This probability is called the propensity score. Ideally, all variables influencing the decision to learn a musical instrument should be included in the selection model. Which characteristics are likely to influence the decision to learn a musical instrument? From a theoretical perspective, enrollment into music lessons is likely to depend both on utility and taste. On the one hand, learning a musical instrument may be motivated by expected utility. In addition to the direct utility derived from making music, parents are likely to enroll their child in music lessons with the motive to invest in their child's future success. Hereby, it does not matter whether the future success stems from skills acquired through music education or from the positive signal sent to school teachers. On the other hand, the enrollment into music classes may depend on taste. Parents might enroll their children into music lessons because their previous experience – their habit – of consuming arts has developed a preference for the arts, as postulated in the learning-by-consuming approach (Garboua and Montmarquette 1996). A taste for the arts also depends on the educational level if we assume that higher educated parents are more able to appreciate artistic activities and consumption (Lunn and Kelly 2009). Finally, better educated parents might be more likely to enroll their children in music lessons, because the offer of artistic activities might be adapted to the tastes if the better educated (Lunn and Kelly 2009).

How can we take these determinants of the decision to learn a musical instrument into account in our selection model? First of all, both utility-motivated and taste-based reasons are related to socio-economic status. We therefore control for parental education, qualification and nationality as well as household net income and the mother's age at birth. In addition, we include variables approximating the complications involved with enrolling a child into music lessons: the number of rooms per person at home, whether the household lives in a rural area and whether it lives near a sports facility. Moreover, parents are more likely to consider music lessons as an investment into future skills if they are more involved with the child's school activities in general. Therefore, we control for their contact with their child's school, which is measured by variables indicating whether the parents help with homework, regularly meet the teacher or engage with the child's school in any other way. Also the personality of the parents might play a role in their eagerness to invest into their child's skill development.

The parents' taste for the arts was approximated with their participation at cultural events as well as their own artistic activities. Moreover, we include a variable indicating the parents' openness towards the arts, which is one of three questions assessing the openness among the Big Five

⁶This 'double-robustness property' is, however, less evident if the variables in the selection model are identical to those included in the regression-adjustment after matching (Huber, Lechner and Steinmayr 2012a, p. 10)

personality traits. To complete the selection model, we include sample⁷, region and birth year fixed effects as all as a dummy variable indicating if the household lives in East Germany. For all parental variables, values of the mother were used. If those were not available, the father's values were included in order to increase sample size.

Ideally, the selection model as well as the matching would be conducted separately for boys and girls. Unfortunately, reducing our sample in half would considerably reduce the match quality. Therefore, our main specification matches boys and girls in a common step using gender as one of the control variables. However, our results are robust to separating the samples for the matching procedure. Another conceivable method could be to do an exact match on gender and propensity score matching for all other covariates, however, this amounts to the same as separately estimating the model for boys and girls.

In order to investigate how well these parental characteristics explain the correlation between music practice and cognitive and non-cognitive skills, we proceed in four steps. In addition to showing a simple correlation without control variables, we carry out three different estimates using propensity score matching in which we successively include groups of control variables. First, we only control for the parents' socio-economic status, three geographic indicators as well as sample, birth and region fixed effects. Second, we additionally include the parents' involvement with the child's school achievement as well as the parents' personality. Finally, we include the variables describing the parents' taste for the arts.

A table showing the coefficients of the three selection models can be found in the appendix (Table 3). Overall, the first selection model is able to explain 15.1 percent of the variation of music practice. This share increases to 16.9 percent for the second and 20.6 percent for the third model, a share which is similar to other papers using selection models (for example Felfe et al. 2011). The coefficients are not surprising: Given that many of the characteristics used to explain selection into music practice are correlated, many coefficients are not significant. It is still recommended to include these insignificant coefficients in the selection model, as the aim is not to find the best model explaining music education but to balance observable (and if possible unobservable) characteristics in treatment and control group as best as possible (Stuart 2010).

Figure 7 in the appendix shows the common support of all three models. The graphs indicate that untreated individuals (children who do not learn a musical instrument) are more likely to have a low propensity score, a further indicator that our selection model predicts musical practice quite well. Still, for the largest part of the distribution, it is possible to find at least one corresponding control observation for each treated individual. Only very few treated observation with very high propensity scores are off support, meaning that we will not be able to find comparable control group observations for them and therefore have to leave them out of the analysis.

Second, once the propensity score is estimated and we have checked the degree of common support, we find matches in the control group for each treated individual. We use radius matching with a caliper of 2 percent, meaning that we give equal weight to each control observation having a propensity score in the range of 2 percent around the corresponding treated observation. The equal weights of the control observations being matched to one treated observation are chosen to sum to 1.

After matching we can check whether the covariates are balanced between treatment and control group. Table xx shows how the covariates are balanced after matching. [... Include table with balancing properties ...]

After adjustment by matching we obtain the correlation between music practice and cognitive and non-cognitive skills in an weighted least square regression weighting each control observation according to the weight that observation obtained in the matching process. In this weighted least square regression, the outcome of interest is the dependent variable and the treatment as well as

⁷The SOEP consists of several samples which were added over time in order to increase the entire sample size of the SOEP. In some of these samples, parts of the population were overrepresented (foreigners, families with many children or high-income families).

any further control variables are the explanatory variables. If our selection model is able to control for all relevant variables, we estimate the average treatment effect on the treated. Algebraically, the average treatment effect on the treated is:

$$A\hat{T}T = \frac{1}{N_T} \sum_{i=1}^{N_T} T_i(y_i|X_i) - \frac{1}{N_C} \sum_{i=1}^{N_C} (1 - T_i)\hat{w}(y_i|X_i) \quad (1)$$

where N_T and N_C are the number of treated and control observations, T_i is the treatment dummy, y_i the outcome and X_i any further control variables of individual i . In our main estimates, the only further control variable we include in X_i is whether the individual went to high school (Gymnasium) after primary school. Control observations are weighted with weight \hat{w} , which is obtained from matching as described above. Standard errors are estimated by bootstrap with 4999 replications⁸.

Under the assumption of conditional independence, we could interpret the correlation between music and skills obtained with the matching estimator as a causal consequence of music practice (Imbens and Wooldridge 2008). With other words, we would have to assume that given the covariates included in the selection model, the decision to learn a musical instrument is as good as random. Despite the very good availability of control variables, we will cannot entirely exclude the possibility that some of the selection is driven by unobservable characteristics which also influence our outcomes of interest. In particular, the lack of pre-treatment outcome variables, as for example cognitive skills at the age of 8, considerably deteriorate our possibilities of approximating such unobserved effects. We will discuss in Section 6 whether the conditional independence assumption is realistic and whether the correlations we estimate hint towards a causal effect of learning a musical instrument.

5 Results

If we look at the educational achievement, personality and ambition of children who learn a musical instrument without taking selection into musical practice into account, we observe huge differences compared to those who do not learn a musical instrument. Clearly, family background characteristics are responsible for at least part of these differences. As described before, children who learn a musical instrument typically have parents who earn more, are more educated, more involved with the child's school achievement and have a stronger taste for the arts than the parents of children who do not learn a musical instrument. Of course, these systematic differences influence both the decision to learn a musical instrument as well as the outcomes of interest.

However, even if we take all observed family characteristics into account as described in Section 4, children who learn a musical instrument still fare much better. Figures 2 to 4 show the outcome differences at age 17 between children who learn a musical instrument and those who do not. Differences in cognitive skills and school marks (Figure 2), personality (Figure 3) as well as optimism for future professional success (last two outcomes in Figure 4) are measured in terms of standard deviation. Differences in time use and educational ambition (first four outcomes in Figure 4) are stated in percentage points. For each outcome, the bar on the left indicates the mean difference between both groups of children without taking selection into musical practice into account. The other three bars show the outcome differences using regression-adjusted propensity score matching with subsequently added control variables (as described in Section 4). In the second bar from the left, we control for parental background, a few geographic characteristics as well as sample, region and birth year fixed effects. The third bar shows the outcome differences controlling additionally for the parents' personality and involvement with school. The darkest bar on the right shows the correlation of music practice and each outcome controlling in addition for the parents' taste for the arts. A table containing the same results can be found in the appendix (Table 4). A

⁸An analytical approximation would be possible, but is not recommended by Huber et al. (2012a)

Text Box: Summary of all variables included to control for selection into musical practice

Parental background characteristics: Parents have no degree, parents have completed only 9 school years, parents have vocational degree, parents have university degree, monthly household log net income (simple and squared), parents have foreign nationality, mother's age at birth, number of siblings, child is the firstborn, rooms per person at home, gender, birth year dummies

Geographic controls: Sports facility less than 10 minutes away, rural area, East Germany, region dummies, SOEP sub-sample dummies

Parents' involvement and personality: parents care about school achievement, parents do not support learning, conflict with parents due to school results, parents attend parent-teacher meetings, parents attend teacher's consultation hours, parents actively contact school teachers, parents engage as parent representatives, parents do not engage with child's, Big Five of parents: conscientiousness, extraversion, neuroticism, agreeableness, openness

Parents' taste for the arts: Parenty monthly attend cultural events, parents never attend cultural events, parents are monthly artistically active, parents are never artistically active, Appreciation for the arts

Later input, included in regression-adjustment but not in selection model: Attending upper secondary school (high school) after primary school

summary of all variables which were taken into account in either the selection model or in the regression-adjustment after matching are summarized in the text box.

Figure 2 shows that observable characteristics are able to explain half of the advantage children learning a musical instrument have in terms of cognitive skills and school marks. Still, a substantial part of the difference between both groups remains unexplained even after controlling for a large number of covariates. We can see that in the cognitive test, children who learn a musical instrument score on average 0.27 standard deviations higher than other children. This difference is driven in particular by higher scores for word analogies and figures. Children learning a musical instrument do not seem to be better able to complete mathematical calculations with the correct operators. When it comes to school marks, more than half of the differences between children who learn a musical instrument and those who do not can be explained with observable characteristics. Once these are taken into account, the average and mathematics marks of children who learn a musical instrument are on average 0.12 to 0.14 standard deviations better than those of other children⁹. These differences are, however, not significant.

Personality differences between children who learn a musical instrument and their peers are explainable by their social background to a lesser extent. As we can see in Figure 3, differences are largest with respect to openness. Without taking the social background into account, children who learn a musical instrument exhibit more openness to the extent of almost half a standard deviation. This difference remains large and significant at almost a third of a standard deviation after controlling for social background characteristics. Moreover, children who learn a musical instrument are a quarter of a standard deviation more conscientious than other children, a difference which is lower if we do not control for observable characteristics. Learning a musical instrument is not associated with higher agreeableness once we control for observable characteristics. Finally, contrary to what one would expect, children who learn a musical instrument have a lower internal locus of control.

If we look at time use and concrete educational ambitions (Figure 4), we can see that an important part of the difference between children who learn a musical instrument and those who do not can be explained with family background characteristics. Once these are taken into account, however, we still see systematic differences between both groups. Children who learn a musical instrument are 12 percent less likely to watch TV every day. Moreover, they are about 12 percent

⁹Please note that in Germany, lower marks are better

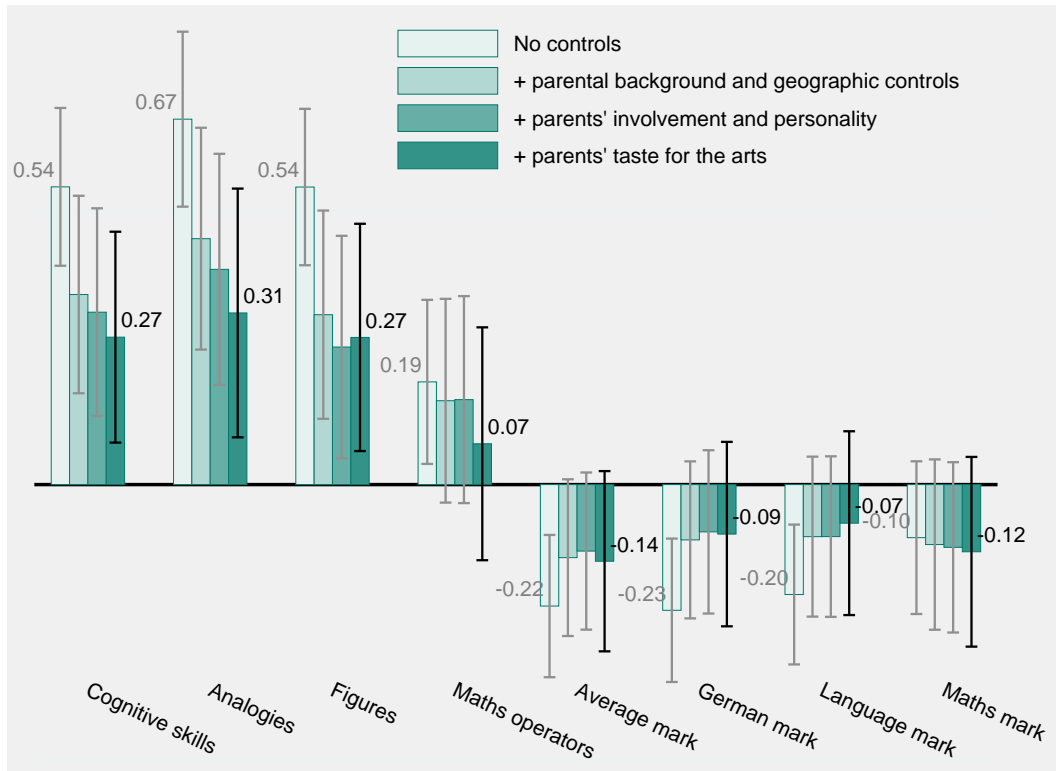


Figure 2 – Mean differences in cognitive skills and school marks between children who learn a musical instrument and those who do not (in standard deviations, including 95% confidence intervals). Note that in Germany, better achievement is rewarded with a lower mark.

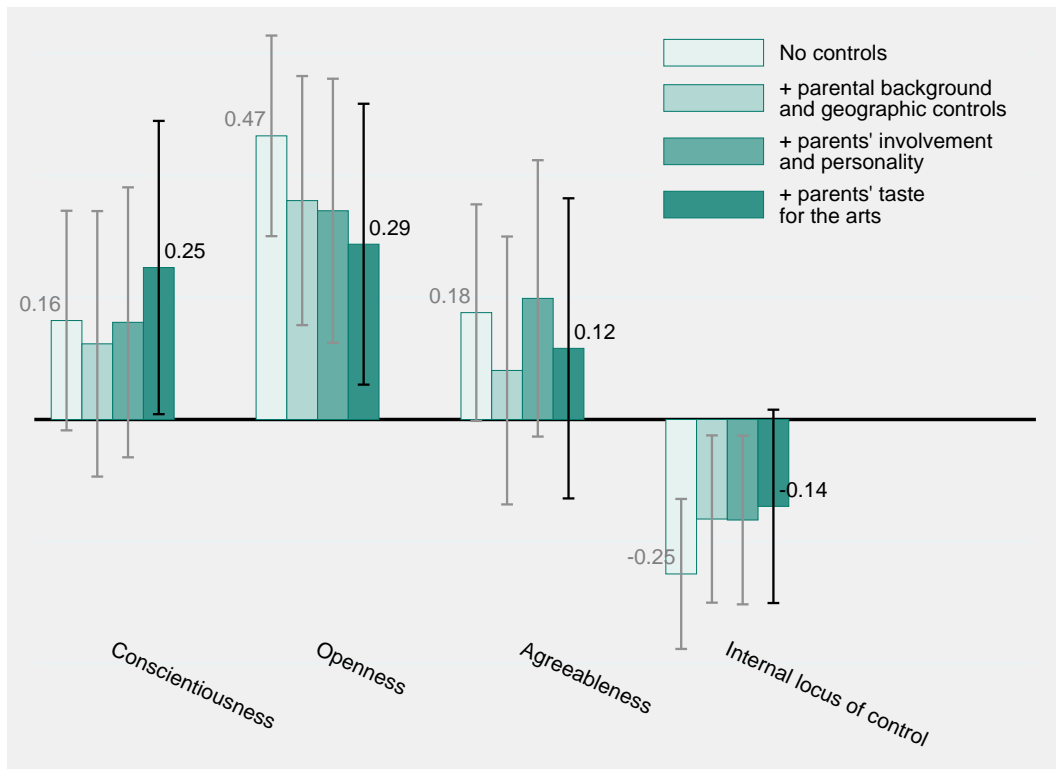


Figure 3 – Differences in personality dimensions between children who learn a musical instrument and those who do not (in standard deviations, including 95% confidence intervals).

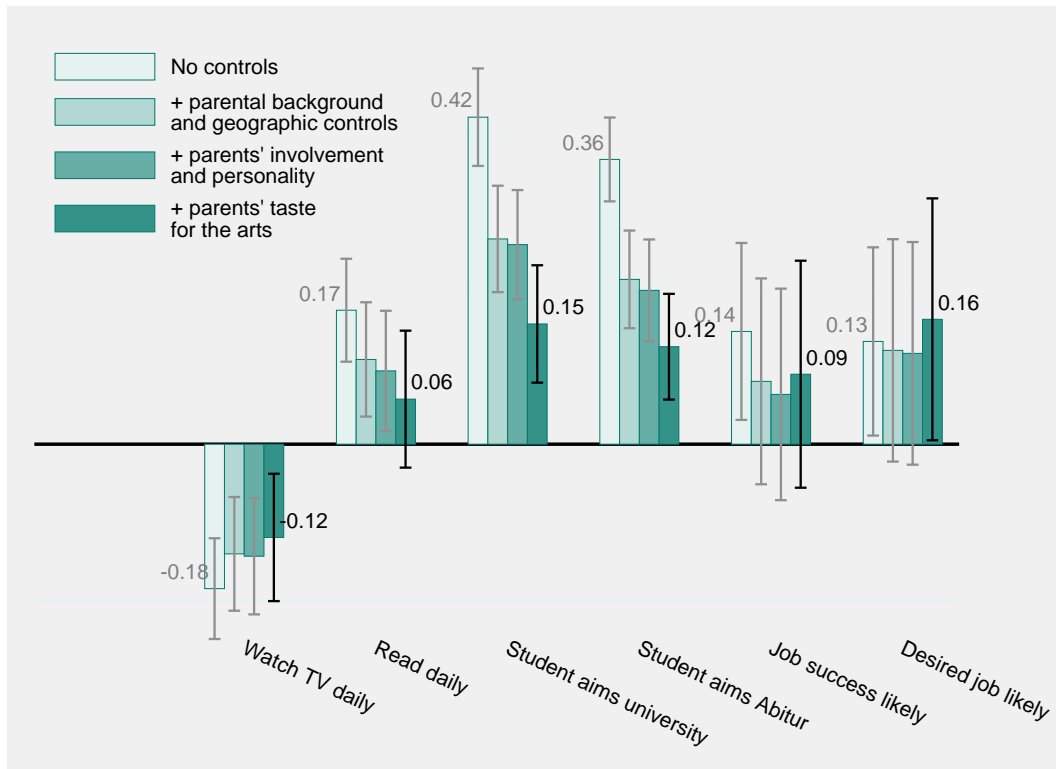


Figure 4 – Differences in time use and ambition between children who learn a musical instrument and those who do not (the first four outcomes are measured in percentage points, the latter two in standard deviations, including 95% confidence intervals).

more likely to plan to obtain a high school degree and 15 percent more likely to aim university enrollment. Note that these differences already take into account whether the individual actually attends high school. Finally, children who learn a musical instrument are more optimistic about their career prospects. They assign a higher probability of a sixth of a standard deviation to find the job they desire.

All of the results presented here are robust to different treatment definitions, control variable specifications and sample restrictions. For example, the results stay very similar if our treatment definition does not require a treated individual to actually follow music lessons. Including individuals who started music lessons at age 9 or 10 or even later does not fundamentally alter our results. Furthermore, our results are not sensitive to minor modifications in the choice of control variables. In terms of the composition of the sample studied, we do not find different outcomes if we drop the observations of individuals who started their treatment later than age 8 instead of including them in the control group. Finally, our results are robust to the results of an analysis within the subsample of individuals whose parents entered the SOEP before they actually started their music lessons.

Figures 5 and 6 show the differences between children who learn a musical instrument and those who do not separately by socio-economic status. Here, both bars indicate the estimated outcome difference using regression-adjusted propensity score matching with all control variables. Given that among families with low socio-economic status, only very few children learn a musical instrument, we need to define this category in a relatively broad manner in order to maintain a sufficient number of observations. Therefore, children from low and medium socio-economic status are those whose parents have no more than a vocational school degree (Realschulabschluss). Children from high socio-economic status are defined as those with parents who have either a high school (Abitur) or university degree. Due to the smaller sample size, confidence intervals are now much larger.

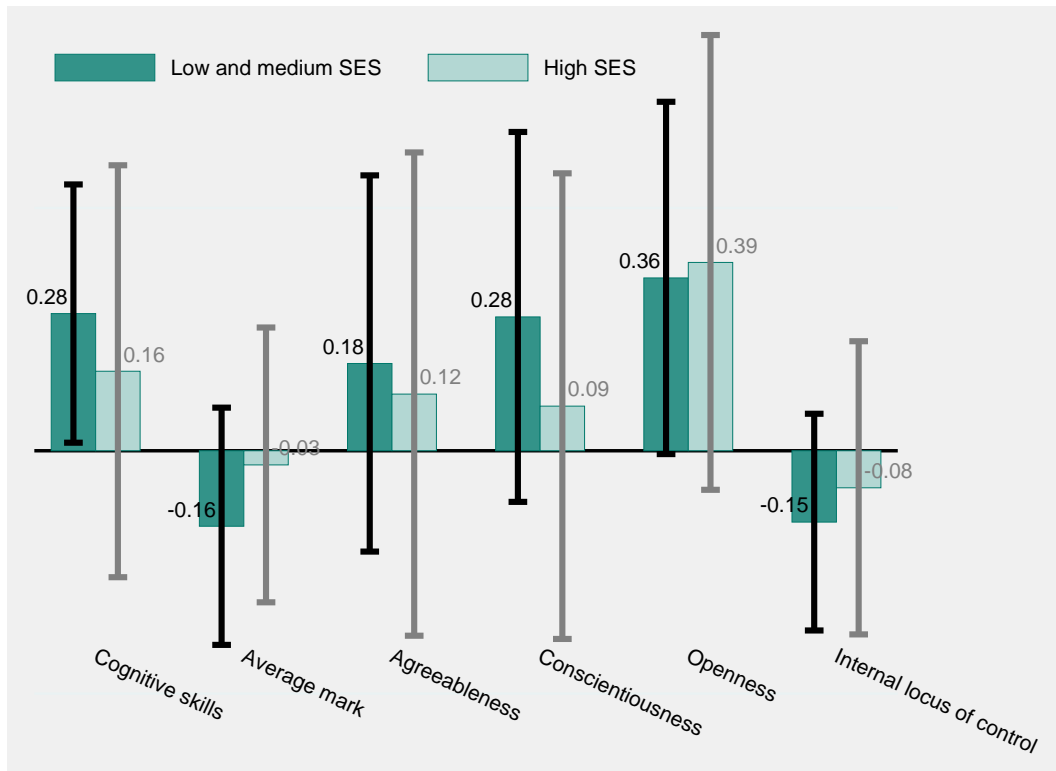


Figure 5 – Differences in time use and ambition between children who learn a musical instrument and those who do not by socio-economic status (in standard deviations, including 95% confidence intervals).

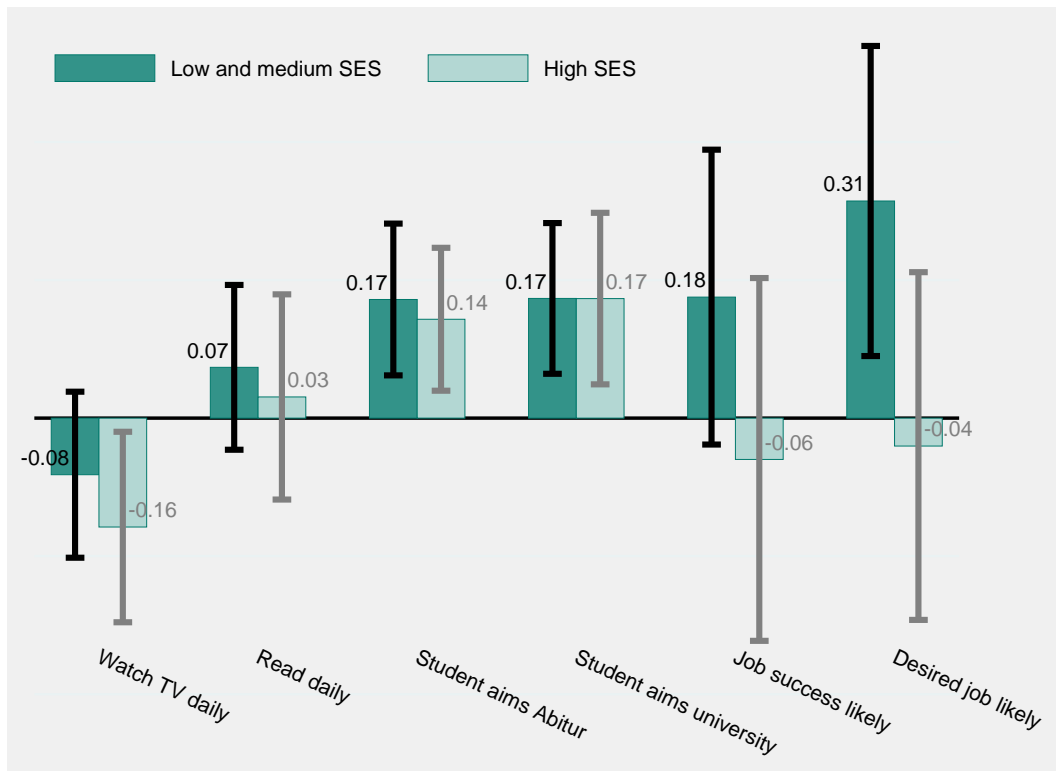


Figure 6 – Differences in time use and ambition between children who learn a musical instrument and those who do not by socio-economic status (the first four outcomes are measured in percentage points, the latter two in standard deviations, including 95% confidence intervals).

We can see that outcome differences are very similar for children with low and high socio-economic status. However, some differences can be observed. Compared to children from high socio-economic background, the difference between children learning a musical instrument and other children in terms of cognitive skills and the average mark is particularly strong among children from low and medium socio-economic status. Similarly, differences are larger among children from low and medium socio-economic status when it comes to conscientiousness as well as the two variables indicating the adolescent's optimism for the future. Only one difference is larger among children from high socio-economic status: the proportion of children watching TV daily. We cannot tell whether any of these differences between children from high and low or medium socio-economic status are statistically significant due to the small sample size.

6 Discussion

In summary, we can state that even after controlling for a large number of social background characteristics, the parents' personality, involvement in education as well as taste for the arts, we still find strong differences in terms of cognitive and non-cognitive skills between adolescents who learn a musical instrument and those who do not. Can these effects be interpreted as causal effects of learning a musical instrument? This section discusses three concerns we might have with a causal interpretation and to which extent they are valid and can be tested.

Can we believe the conditional independence assumption? The average treatment effect of the treatment obtained from the propensity score matching estimator can be interpreted as a causal effect if the conditional independence assumption is valid. In this study, this means that given the control variables included in the selection model, enrollment in music lessons is as good as random. Such an assumption would be invalidated if there were unobserved characteristics which influence the decision to learn a musical instrument and at the same time have an impact on the outcome variables we are interested in. For example, inherently more motivated children could be more likely to learn a musical instrument and at the same time develop better cognitive skills. Similarly, children from parents who are more involved monitoring their child's school performance could enroll their child into music classes and at the same time make sure they develop more ambitious educational plans. In both cases, the better outcome is not a consequence of music lessons, but both music lessons and the better outcome are a consequence of the unobserved characteristics of the parents or the child itself.

The influence of unobserved characteristic invalidates a causal interpretation of our results only to the extent that these unobserved characteristics are uncorrelated with the observed characteristics we control for (Stuart 2010). If the intrinsic motivation of the child is strongly correlated with the personality and socio-economic status of its parents, we do not have to worry that it is not included as a control variable. However, we cannot exclude the possibility that we are unable to control for some of the unobserved characteristics which drive the outcome differences between children who learn a musical instrument and those who do not.

We have two reasons to believe that we actually control for most of the variables determining selection into music practice. First, according to our treatment definition, a child is considered as having learned a musical instrument if she or he started to learn the instrument before the age of 8. We argue that at such a young age, the decision to engage in a long-term extracurricular activity such as music is strongly determined by the parents. For the parents, however, we observe a very large number of background characteristics, in particular their socio-economic status, personality, involvement with education and taste for the arts. All of these observed characteristics are strongly correlated among each other and therefore also likely to be strongly correlated with any unobserved characteristics we might miss. Hence, we should be mainly concerned about unobserved characteristics of the child itself. The following argument as well as the discussion on reverse causality below give a hint why we think that even for children, unobserved characteristics

cannot entirely explain our estimated outcome differences.

One of the most important predictors of educational achievement is whether the child goes to high school. Whether the child goes to high school is determined by a variety of background characteristics, some of which are unobservable to us. Therefore, controlling for high school will help us capture some of the child's unobserved characteristics. Moreover, whether the child goes to high school might also be determined by the fact that it learns a musical instrument. Controlling for high school thus also captures some of the treatment effect we are interested in. All in all, controlling for whether the child goes to high school should help us reduce the selection bias resulting from unobserved characteristics and may even lead us to underestimate the true effect of learning a musical instrument.

Are the results due to reverse causality or simultaneity? A possible explanation of the positive association between music and cognitive as well as non-cognitive skills could be reverse causality or simultaneity. For example, making music does not increase ambition, but the more ambitious children learn a musical instrument. Similarly, reverse causality could explain the positive correlation of music lessons with other outcomes such as openness, agreeableness, or even cognitive skills and school marks. Ideally, we would exclude the possibility of reverse causality by controlling for the value of the outcome before the start of music lessons. Unfortunately, we only measure our outcome variables once, at the age of 17.

Two tests show that our results are probably not driven by reverse causality. First, we examine the robustness of our results to including some of the outcomes as control variables. Of course, once we control for a particular outcome, we can no longer test the influence of music lessons on that outcome. However, we can check how the effect of music lessons on the other outcomes changes. The theoretical idea of this test is to consider the skill level measured at age 17 as a proxy for same skills earlier in childhood. With this additional control variable, we can test for example how learning a musical instrument influences cognitive skills controlling for conscientiousness. [... Add discussion on the underlying assumptions of such an approach linking to the literature of mediation analysis ...]

We estimated the effect of learning a musical instrument on all outcomes described above controlling successively for conscientiousness, openness, agreeableness, cognitive skills, the desire to obtain a high school degree (Abitur), the desire to enroll in university, the likelihood of finding the desired job as well as the likelihood of professional success. In each of these regressions, the correlation between learning a musical instrument and the outcome we control for is – of course – eliminated. However, the pattern of effects for all other outcomes remains very stable. Only the correlation between music and school marks, which is already weak and insignificant in the baseline model, is eliminated once we control for educational ambitions. All of these results can be provided by the authors on request.

Second, we argue that the decision to learn a musical instrument at an early age is not driven by the personality or ambition of the child. As stated earlier, we define our treatment as learning a musical instrument at the age of 8 and having music lessons. We argue that at this age, the decision to learn a musical instrument is strongly influenced by the parents, for whom we observe relevant variables such as personality, cultural participation and socio-economic status. Had we included children who started to learn a musical instrument at a later age in our treatment group, we might indeed face the issue of reverse causality, because at a later age, the child's personality might play a greater role in the decision to make music.

We can test the hypotheses that the child's personality does not play such an important role in the decision to learn a musical instrument using data from the new mother-child questionnaires, which were introduced in the SOEP for children born after 2003. These questionnaires assess among other things the child's personality at age 3, 6, 8 and 10¹⁰. Unfortunately, these chil-

¹⁰The parents are asked to evaluate the child's personality by responding to questions such as "My child tends to be talkative/quiet" or "My child tends to be sweet-tempered/easily excited"

dren are too young to be in our main sample of young adults. Therefore, we do not observe any of the outcome variables for them. However, since 2006 the SOEP household questionnaire biannually asks parents whether their child is learning a musical instrument. Hence it is possible to test the importance of personality skills as predictors for learning a musical instrument once we control for the parental variables of our selection model.

[... results to be added here ...]

Partly treated individuals in the control group – do we over- or underestimate the true treatment effect? As explained before, some of the individuals in our control group have received music lessons for some years. They are in the control either because they started to learn a musical instrument later than age 8 or because they finished making music before age 17. We can identify the first group of individuals because if someone still plays a musical instrument at the age of 17, she or he is also asked at which age music activity was taken up. However, we are not able to identify individuals who learned a musical instrument earlier in their life and then stopped, because the youth questionnaire does not ask them about musical practice in the past.

Independently of the conditional independence assumption discussed above, the existence of partly treated individuals in the control group influences the direction in which our estimates of the effect of learning a musical instrument differ from the true treatment effect. If these partly treated individuals also benefit to some extent from learning a musical instrument, we do not have to worry. In this case, our estimates of the effect of learning a musical instrument can be considered as a lower bound of the true effect, given that some members of the control group also benefit from the treatment. A more worrisome conclusion would follow if these partly treated individuals suffered from their music practice. If the true effect of learning a musical instrument was positive for those who make music from age 8 to 17, but negative for those who play for a shorter period, we would overestimate the true effect even if the conditional independence assumption was valid. In this case, our estimated effect would add up the positive effect in the treatment group and the negative effect for the others. In order to obtain the true treatment effect, we should have subtracted these effects from each other.

In practice, partly treated individuals weakly benefit from learning a musical instrument. Therefore, including them in the control group leads us to estimate a lower bound of the treatment effect of learning a musical instrument if the conditional independence assumption is valid. Learning a musical instrument later than the age of 8 is associated with weaker, but still positive benefits in terms of school achievement, non-cognitive skills and ambition compared children who start to learn a musical instrument earlier. The effect on cognitive skills, however, vanishes for this group. This is not surprising if we believe that those who start to learn a musical instrument later are less influenced by their parents. Rather, they decide to want to learn a musical instrument. Even if music as such has no effect on these children, they are likely to be equipped with a stronger sense of determination, which also leads to better school marks and ambition. Cognitive skills and personality are more difficult to be influenced.

The effect of music on children who stopped learning a musical instrument before they answer the SOEP youth questionnaire at age 17 is more difficult to predict. Around 60 percent of children who start to learn a musical instrument stop in their early teenage years. The reason why they stop are [... add results from study study on ending music practice during teenage years ...]. Hence, it would not be surprising if they stopped playing a musical instrument because music has a negative effect on their school performance. We can test this hypotheses thanks to the SOEP household questionnaire, which biannually asks parents about the free-time activities of their children since 2006. As these questions were introduced in the SOEP only in 2006, we cannot examine the outcomes of children who stopped playing a musical instrument for the entire sample. Among the children in our sample with valid outcome variables (who answered the SOEP youth questionnaire), we only observe 26 of children who indicated in 2006 or 2008 that they played a musical instrument, but no longer did so 2 or 4 years later. Moreover, we observe 309 individuals, who

state that they did not play a musical instrument in any year, meaning that we are certain that they did not learn a musical instrument after the age of 12. We estimate outcome differences between adolescents playing a musical instrument until younger than the age of 17 compared to those who never played a musical instrument after the age of 12.

Indeed, children who stop playing a musical instrument during their early teenage years only benefit weakly from their music practice. When it comes to cognitive skills, these children even score worse than children who never learned a musical instrument. For the causal interpretation of our main results, this means that we might overestimate the true effect of music on cognitive skills, because some of the partly treated individuals might actually suffer from music. Contrarily, including partly treated individuals in our control group rather leads us to *underestimate* the effect of music on personality, time use and ambition.

[... put results graph here ...]

7 Conclusion

Children who learn a musical instrument typically have parents who are more educated, earn more, are more involved in their child's school activities, participate at cultural activities and sometimes are even artistically active themselves. It is therefore not surprising that these children benefit from higher cognitive and non-cognitive skills. However, these differences in parental background only explain part of the advantage in skill development. The present study shows that even after controlling for these background differences, learning a musical instrument is associated with better cognitive and non-cognitive skills.

We have shown that learning a musical instrument during childhood is associated with better cognitive skills, school marks, personality, time use and ambition. Adolescents who have learned a musical instrument score 0.27 standard deviations above other children in a cognitive skills test. Their average school mark is 0.14 standard deviations better, whereas this difference is only slightly significant. Adolescents who make music are more conscientious (0.25 standard deviations) and more open (0.29 standard deviations). They are 12 percent less likely to watch TV, 12 percent more likely to aim a high school degree and 15 percent more likely to enroll in university studies. Moreover, they are more optimistic that they will find a job in their desired profession (0.16 standard deviations). We also find a heterogeneity in the correlation in terms of socio-economic status. Adolescents from low and medium socio-economic status who learn a musical instrument differ more from their peers than children from high socio-economic status in the following dimensions: cognitive skills, average school mark, conscientiousness and the optimism to find the desired job and to have professional success. Adolescents from families with high socio-economic status are more likely to watch less TV than those from lower socio-economic status.

Is there a causal effect of learning a musical instrument? First, the effects we estimate are strong in magnitude and robust. [... add comparison of the effect size with other effect sizes ...] Even if not the entire effect can be interpreted as a causal effect of music practice, the positive correlations we find are very robust with respect to different model specifications, treatment definitions and sample restrictions.

Second, we cannot eliminate the possibility of an endogeneity bias due to the non-random selection into music practice. However, we study the effect of learning a musical instrument for individuals who have started to learn a musical instrument before the age of 8 years. We argue that at such a young age, the decision to learn a musical instrument is mainly driven by the parents. For the parents, however, we observe many characteristics which might influence this decision. In particular, we are able to control for the parents education, nationality and income. In addition, we take into account the parents' personality, their involvement in the child's school achievement, their cultural participation and activities as well as their openness towards the arts. We cannot exclude the possibility that further, unobserved characteristics determine both the decision to learn a musical instrument, which are uncorrelated with the observed characteristics we control for.

Third, the most important weakness of our data is the fact that we do not observe any of the outcome variables prior to the start of the treatment. A causal interpretation of our estimates might therefore be rejected for reasons of reverse causality. We try to exclude the possibility of reverse causality by examining the correlation between music practice and cognitive and non-cognitive skills while subsequently controlling for cognitive and non-cognitive skills as well as school marks. We observe that the pattern of correlation between music and cognitive and non-cognitive skills does not vary when we include any of the outcome variables as controls.

Fourth, some individuals in our control group have received music lessons either until earlier than age 17 or starting later than age 8. If these partly treated individuals suffer from learning a musical instrument, we would therefore overestimate the true effect of learning a musical instrument, independently of the validity of the conditional independence assumption. This is especially worrisome for those individuals who have ended their music lessons before the age of 17 because the questions asked in the SOEP Youth Questionnaire are not able to identify them. However, some tests on the effect of music in those subgroups, as presented in Section 6, show that the only outcomes for which such a risk of overestimation is present are cognitive skills. This test is, however, based on a very small sample size.

The strong correlations between learning a musical instrument and a variety of cognitive and non-cognitive skills – even after controlling for many covariates – shows us that music is potentially an important input in the skill production function (Cunha and Heckman 2008, Todd and Wolpin 2003). More research should be carried out to understand the causal influence of music practice in the development of skills. In our view, three challenges should determine the agenda on future research on this question. The most important challenge will be to separate the influence of parental background from the influence of music lessons. In order to do so, it will be necessary to identify a variable which influences the decision to learn a musical instrument without influencing the development of skills. Policy interventions and other variations in the regional availability of music lessons might be a promising way to realize causal studies on the effects of music by providing a truly exogenous selection into treatment.

A second challenge will be to answer the question to which extent extracurricular activities are substitutable. Similar policies as those described in the introduction exist, which propose theatre lessons or physical activities for children from disadvantaged social backgrounds. As stated before, several studies like the one by Covay and Carbonaro (2010) find positive effects on skill development of extracurricular activities in general. The only other activity assessed in detail in the SOEP Youth Questionnaire is whether adolescents were active in sports during their childhood. Further research on the potential of different types of activities should be carried out by carefully modelling the interaction between them, given that they can be both a substitute or a complement.

Finally, further research should investigate the long-term effects of learning a musical instrument. It is possible that learning a musical instrument has long-term positive effects beyond educational achievement. Maybe the skills acquired from music lessons are not helpful in improving school results or the attainment of educational degrees, but constitute an advantage at the moment of entering the labor market.

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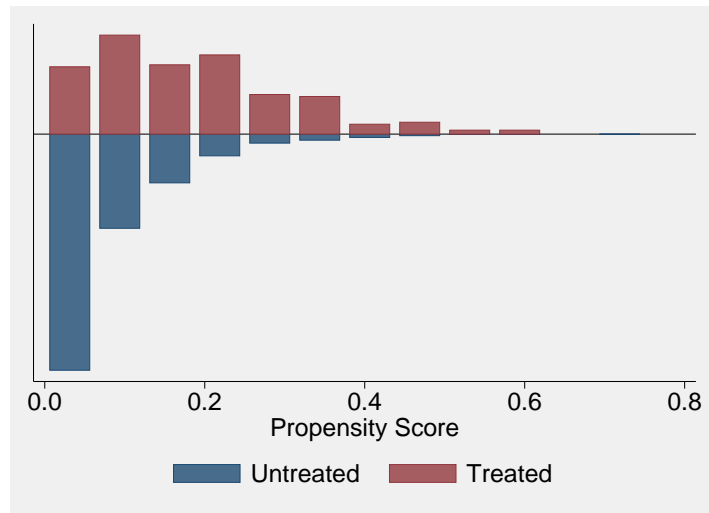
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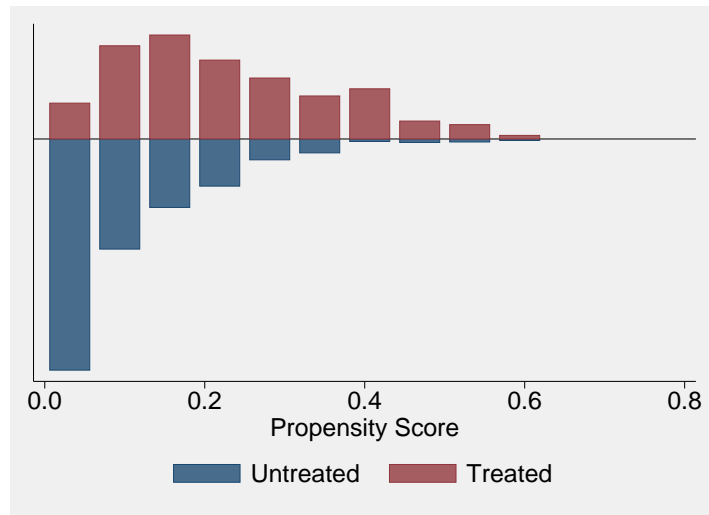
	Model 1	Model 2	Model 3
Have music lessons before age 8			
<i>Parents' socio-economic status</i>			
Mother has university degree	0.10 (0.16)	0.07 (0.17)	0.01 (0.17)
Mother only finished 9 years of school	-0.22* (0.11)	-0.17 (0.11)	-0.05 (0.12)
Mother has no degree	-0.49** (0.24)	-0.42* (0.24)	-0.30 (0.25)
Mother has vocational degree	-0.10 (0.18)	-0.08 (0.18)	-0.05 (0.18)
Monthly HH net income (log, in Euros)	-0.93 (1.48)	-0.98 (1.54)	-1.16 (1.53)
Mother has foreign nationality	-0.18 (0.21)	-0.15 (0.21)	-0.10 (0.22)
The respondent is a girl	0.45*** (0.08)	0.47*** (0.08)	0.47*** (0.09)
Monthly net log HH income (square)	0.08 (0.10)	0.08 (0.10)	0.09 (0.10)
Oldest child in family	0.13 (0.09)	0.09 (0.09)	0.07 (0.09)
Number of siblings (in SOEP)	0.05 (0.03)	0.05 (0.03)	0.06* (0.04)
Rooms per person in family home	0.29*** (0.10)	0.28*** (0.10)	0.25** (0.11)
Mother's age at birth	0.02** (0.01)	0.02** (0.01)	0.01 (0.01)
<i>Geographic characteristics</i>			
Less than 10 minutes to sports facility	-0.02 (0.08)	-0.05 (0.08)	-0.07 (0.09)
Rural area	-0.07 (0.13)	-0.05 (0.13)	-0.10 (0.14)
East Germany	-0.28 (0.48)	-0.34 (0.47)	-0.39 (0.47)
<i>Parents' involvement with school</i>			
Parents care strongly about achievement		0.03 (0.10)	0.07 (0.10)
Parents don't support learning		-0.07 (0.10)	-0.04 (0.11)
Conflict with parents due to school results		-0.01 (0.08)	0.00 (0.08)
Parents go to parent-teacher meeting		0.21* (0.12)	0.16 (0.12)
Parents go to teacher's consultation hours		-0.13 (0.09)	-0.13 (0.09)
Parents actively contact school teachers		0.18* (0.09)	0.15 (0.10)
Parents engage as parent representatives		0.29*** (0.10)	0.24** (0.10)
Parents don't engage with the child's school		0.10 (0.19)	0.11 (0.20)
<i>Personality of parents</i>			
Conscientiousness (parents)		-0.41 (0.38)	-0.32 (0.40)
Extraversion (parents)		-0.57** (0.28)	-0.41 (0.28)
Agreeableness (parents)		0.13 (0.32)	0.13 (0.33)
Openness (parents)		0.72*** (0.27)	-0.39 (0.44)
Neuroticism (parents)		-0.02 (0.23)	0.14 (0.24)
<i>Parents' taste for the arts</i>			
Mother never attends cultural events			-0.39*** (0.11)
Mother monthly attends cultural events			0.26** (0.12)
Mother is never artistically active			-0.37*** (0.11)
Mother is artistically active monthly			-0.00 (0.10)
Appreciation for art (parents)			0.70** (0.28)
Constant	-0.87 (5.80)	-0.54 (6.00)	0.86 (5.97)
Sample, birth and region fixed effects	Yes	Yes	Yes
Number of observations	2367	2367	2367
Pseudo-R-Square	0.151	0.169	0.206

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

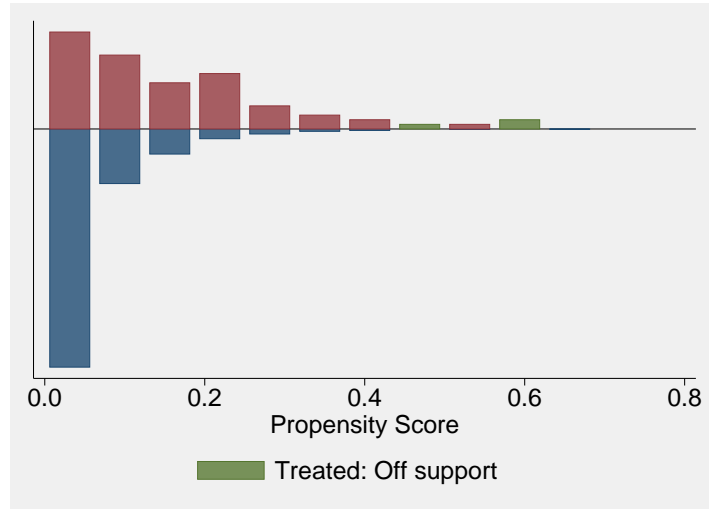
Table 3 – Selection model (probit)



(a) *Model 1 (Parental background and geographic characteristics as controls)*



(b) *Model 2 (All control variables except parents' taste for the arts)*



(c) *Model 3 (All control variables)*

Figure 7 – *Common support for the three selection models*

	No music	Music	Difference	P-value	N
<i>Cognitive skills</i>					
Average cognitive skills	0.23	0.50	0.27	0.01	1446
Analogies	0.31	0.63	0.31	0.01	1465
Figures	0.25	0.52	0.27	0.01	1460
Maths operators	0.08	0.16	0.07	0.49	1457
<i>School achievement</i>					
Average school mark	-0.11	-0.25	-0.14	0.10	2358
German mark	-0.17	-0.26	-0.09	0.29	2425
Foreign language mark	-0.14	-0.21	-0.07	0.41	2366
Mathematics mark	0.01	-0.12	-0.12	0.17	2421
<i>Personality</i>					
Conscientiousness	-0.07	0.18	0.25	0.04	1273
Openness	0.14	0.43	0.29	0.01	1267
Agreeableness	0.05	0.16	0.12	0.35	1282
Internal locus of control	-0.13	-0.27	-0.14	0.08	2429
<i>Time use</i>					
Watch TV daily	0.73	0.61	-0.12	0.00	2449
Read books daily	0.35	0.41	0.06	0.20	2443
<i>Ambition</i>					
Aim to attain high school degree	0.67	0.80	0.12	0.00	2187
Plan to enroll at university	0.49	0.65	0.15	0.00	2423
Likely to work in desired profession later	0.01	0.16	0.16	0.04	2420
Likely to be successful in job later	0.04	0.13	0.09	0.23	2425

Definition of *music*: Have music lessons before age 8.

Table 4 – Outcome differences between adolescents who learn a musical instrument and those who do not

	No music	Music	Difference	P-value	N
<i>Cognitive skills</i>					
Average cognitive skills	0.12	0.40	0.28	0.04	990
Analogies	0.06	0.43	0.36	0.02	1007
Figures	0.10	0.41	0.31	0.04	1002
Maths operators	0.10	0.16	0.06	0.67	999
<i>School achievement</i>					
Average school mark	0.05	-0.10	-0.16	0.21	1617
German mark	0.01	-0.13	-0.14	0.28	1676
Foreign language mark	0.03	-0.13	-0.17	0.18	1623
Mathematics mark	0.08	0.01	-0.06	0.62	1674
<i>Personality</i>					
Conscientiousness	0.01	0.28	0.28	0.16	849
Openness	0.05	0.41	0.36	0.05	853
Agreeableness	0.03	0.21	0.18	0.36	856
Internal locus of control	-0.02	-0.17	-0.15	0.20	1686
<i>Time use</i>					
Watch TV daily	0.75	0.67	-0.08	0.18	1704
Read books daily	0.29	0.37	0.07	0.23	1698
<i>Ambition</i>					
Aim to attain high school degree	0.52	0.69	0.17	0.00	1467
Plan to enroll at university	0.33	0.51	0.17	0.00	1685
Likely to work in desired profession later	0.02	0.34	0.31	0.01	1675
Likely to be successful in job later	0.07	0.24	0.18	0.11	1680

Definition of *music*: Have music lessons before age 8.

Table 5 – Outcome differences between adolescents from low and medium socio-economic status who learn a musical instrument and those who do not

	No music	Music	Difference	P-value	N
<i>Cognitive skills</i>					
Average cognitive skills	0.55	0.71	0.16	0.45	313
Analogies	0.67	0.83	0.16	0.53	316
Figures	0.41	0.72	0.31	0.20	313
Maths operators	0.32	0.25	-0.06	0.76	316
<i>School achievement</i>					
Average school mark	-0.31	-0.34	-0.03	0.84	849
German mark	-0.33	-0.39	-0.06	0.70	856
Foreign language mark	-0.28	-0.21	0.07	0.63	851
Mathematics mark	-0.15	-0.22	-0.07	0.65	856
<i>Personality</i>					
Conscientiousness	0.04	0.13	0.09	0.71	374
Openness	0.13	0.51	0.39	0.10	360
Agreeableness	-0.00	0.11	0.12	0.65	377
Internal locus of control	-0.28	-0.36	-0.08	0.62	855
<i>Time use</i>					
Watch TV daily	0.70	0.54	-0.16	0.03	858
Read books daily	0.41	0.44	0.03	0.69	856
<i>Ambition</i>					
Aim to attain high school degree	0.77	0.92	0.14	0.01	812
Plan to enroll at university	0.62	0.79	0.17	0.01	845
Likely to work in desired profession later	0.08	0.04	-0.04	0.75	852
Likely to be successful in job later	0.11	0.05	-0.06	0.66	853

Definition of *music*: Have music lessons before age 8.

Table 6 – Outcome differences between adolescents from high socio-economic status who learn a musical instrument and those who do not