

# The Influence of Singing on 15-year-old Students School Performances in Mathematics, Science and Reading Comprehension

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**Abstract** Research suggests that music can act as a catalyst for cognitive skills in other disciplines, and the relation between music and spatial-temporal skills is fascinating. In particular, we are able to confirm, thanks to recent studies, the hypothesis that singing (heard or produced autonomously) improves the learning of language, above all on account of the motivation induced and the better structuring of the discourse within the musical container. However, various questions remain unanswered. Little is known about the precise elements of music education that are positively transferrable to other fields. Moreover, further transversal studies would be necessary to establish the duration of such effects. The study presented here stems precisely from the idea of adding a further step in the understanding of what effect musical and vocal experience, in our case in a family environment, might have on learning as a whole. The study takes into account the results of the survey OECD - PISA 2009 and the answers given by the parents of 2,247,100 fifteen-year-old students about the habit of singing with their children during their early childhood. The results would seem to indicate that the performances of the 15-year-olds in mathematics, science and reading comprehension are positively correlated to the frequency with which they were able to undergo musical-vocal experiences inside the family during their first years of life.

**Keywords:** *sing songs, musical family practices, school performances, 15-year-olds students, OECD- PISA research*

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## 1. Introduction

The value of singing as a vehicle of learning has been investigated widely and from many points of view. The voice is in fact the most immediate musical instrument available to us. Initially a means of expressing emotions and needs, in synergy with body gestures, the voice provides us with language, and later singing, in an evolutive process. This process sees a progressive and extraordinary refinement of articulatory and perceptual skills, which marks the developmental path of man in general and of each individual in particular [1]. Research has also amply demonstrated the advantages of listening to songs performed by other people, especially by those with whom there is a strong emotional bond. Current neurophysiological theories tell us, for instance, that music is clearly a means of improving people's moods and of satisfying our emotional needs [2].

Musical emotions answer primary needs [3] and seem to imitate certain characteristics of verbal language for their transmission. They also invoke some of the same neural regions aroused by language, but music appears to

infiltrate to a much greater extent into the cerebral structures implicated in motivation, gratification and emotion. Musical stimulus involves various wide-spaced regions of the brain, such as the cerebellum at the back of the skull and the frontal lobes immediately behind the eyes, and it triggers a precise play of release and capture of neurotransmitters between the systems of logical prediction and those pertaining to emotional gratification. When we like a piece of music, we are reminded of music we have already heard and mnemonic traces of emotional moments in our life are activated [4].

The relation existing between music and language, as well as the support that the former may offer to the learning of the latter, represents a topic that has been widely discussed over the last few years [5].

Isabelle Perez reports how recent empirical studies suggest that music plays an important role in regulating the emotional communication between the child and those who care for him [6]. Right from birth all mothers and wet-nurses throughout the world sing to their children because their intuition (or instinct) has led them to believe that music has the power to regulate and comfort the child's psychological state by creating an effective form of communicative interaction. Carers, wet-nurses, mothers

and, in general, all the adults that surround the newborn, instinctively sing more slowly when addressing the child, using a higher range of notes, exaggerating the rhythm and, in any case, using a sweeter and more emotional tone than when they sing alone. This, moreover, would seem to be an anthropologically universal and inborn characteristic in humans.

Similarly, adults speak to the newborn in a very particular way, accentuating the connotative character of the language and its musical properties. This phenomenon has been named *baby talk* or *motherese*. Despite this, the child seems to be able to discriminate between 'word' and 'music' at a very early age. Threhub [7] reports a study in which 6-month-old children were shown a videotape recording of their mother while she was either singing or talking to them. The children paid much more attention to the episodes where their mother was singing as opposed to simply speaking. They were hypnotized by these musical performances, staying glued to the screen for very long periods. The mother speaking did not arouse so much interest as the mother who was singing. The fact that the children respond in a particular way to the emotive messages of the music addressed to them highlights the 'adaptive' value of maternal singing. Such emotional communication between mother and child is crucial for survival, and the residues of this early imprinting will have a notable effect throughout their whole life (as various studies in the sector point out) and may explain the reason for the success of learning vehicled by singing, also in the realm of language.

It has been widely demonstrated how songs can help the acquisition of language in various ways. First of all, by involving the emotional aspects, songs can help to raise the level of attention and enhance the auditory memory. Secondly, from a perceptual point of view, the presence of a vocal intonation contour can facilitate phonological discrimination given that the change of syllable is often accompanied by a change in pitch. In the third place, a coherent cross-mapping of musical and linguistic structure can optimize the functioning of the learning mechanisms.

A further advantage of using songs in language learning is that it stimulates the assumption of strategies of convenient perceptual segmentation, that is to say, it offers the chance to reduce the complexity of the perceived structures. The musical structures of songs and nursery rhymes are in fact characterized by a more evident internal segmentation compared to a prose text. A sung text undergoes a threefold segmentation: the verbal-syllabic structure is reinforced at a rhythmic level by the adoption of a stable pulsation; moreover, the melodic profile amplifies and stylizes the prosodic profile of the text.

We are all able intuitively to use the syllabic segmentation of a text to remember the rhythmic structures. It is no mere chance that this was the procedure adopted by Kodaly, Orff and other pedagogists in their active methods for music education.

While we are therefore able to confirm, thanks also to the recent study by Schön et al, the hypothesis that singing (heard or produced autonomously) improves the learning of language above all on account of the motivation induced and the better structuring of the discourse within the musical container [8]. Nevertheless, we have no such specific studies that deal with singing, especially that of the mother to the child, as a facilitator in the learning of

mathematics or the natural sciences. In general terms, Gardiner et al. conclude that, on the basis of the data available to us, it appears that once students have discovered the pleasure of taking part in artistic activities, they are motivated to acquire associated skills which we consider particularly important. This has two consequences. On the one hand, students realize they are able to tackle intellectual challenges that are at the same time gratifying. This can lead to an improvement in their attitude towards learning and towards school as a whole. On the other hand, as a result of the acquisition of artistic skills, the intellectual skills they have fostered are then extended to other fields: the improvement in mathematical tasks deriving from musical experience, for example, can be re-channelled into the training of mental faculties, such as the principle of ordering or other aspects of mathematical thought [9].

A more recent study highlighted how children at risk who had benefitted from keyboard lessons for two years obtained higher marks in a standardized arithmetic test than children from other control groups, including those that had instead had computer lessons. Moreover, children who had received singing lessons obtained higher marks than all the other control groups, while those that had had lessons in the use of rhythm instruments obtained better results in a mathematical reasoning test [10].

Research suggests that music can act as a catalyst for cognitive skills in other disciplines, and the relation between music and spatial-temporal skills is particularly fascinating. However, various questions remain unanswered. Little is known about the precise elements of music education that are positively transferrable to other fields. Moreover, further transversal studies would be necessary to establish the duration of such effects [11].

## 2. 'Singing Songs' and the PISA School Performances

The investigation reported here was undertaken precisely to supply a partial answer to such questions and to help provide a further clue in our understanding of the benefits that musical experience, in our case vocal and sustained in the family environment, might bring to learning as a whole. For this purpose we took into consideration data from the OECD - PISA 2009 research<sup>1</sup> and, in particular, the replies given by the parents of 15-year-old school pupils.

The question asked was formulated as follows:

When your son/daughter was attending the first year of primary school, how often did you (or someone else at home) involve him/her in the following activities?

The question (PA03) was a container for nine multiple-answer items (PA03Q01 to PA03Q09), namely: a) Read books; b) Tell stories; c) Sing songs; d) Play with alphabet toys; e) Talk about things you had done; f) Talk about what you had read; g) Play with word games; h) Write

<sup>1</sup> The most important research project currently existing worldwide. It takes place every three years and investigates the level of competence acquired by 15-year-olds attending all types of school in reading, mathematics and sciences. Every three years one of these disciplines is chosen as the main area of research while the others, in turn, are taken as secondary dominions. In the PISA 2009 study, the main object of research was reading comprehension.

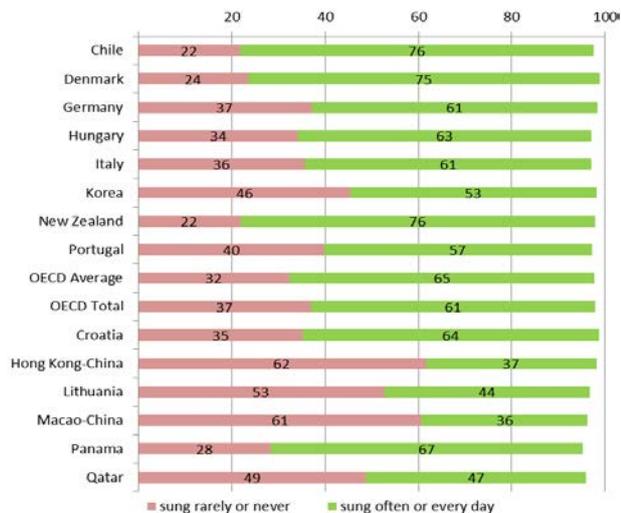
letters or words; i) Read aloud signs. The possible answers were: 1) Never or hardly ever; 2) Once or twice a month; 3) Once or twice a week; 4) Every day or almost every day. Here we will focus on the third item, concretely: c) Sing songs.

The questionnaire aimed at parents was not administered in all OECD member or associated countries in the world, but only in the following states: Chile, Denmark, Germany, Hungary, Italy, Korea, New Zealand, Poland, Portugal, Croatia, Hong Kong, Lithuania, Macao, Panama, Qatar.

The question involved the parents of 3,123,744 15-year-old school pupils (this is a weighted value<sup>2</sup>). However, a valid answer was given by the parents of 2,247,100 students. Hence, the average percentage of those whose parents did not answer was 20%.

The sub-sample formed of the countries that administered the questionnaire satisfies the minimum criteria of representativity according to the criteria adopted by OECD-PISA (the minimum criterion required to guarantee the validity of a questionnaire aimed at a specific group, in this case the parents, is the participation of at least fifteen countries).

The answers from the various participating countries, shown in dichotomized form, can be seen in the following table (Figure 1):



**Figure 1.** Answers given by the parents to the question PA03: Sing songs

## 2.1. 'Sing Songs': Detailed Analysis

To carry out the present study, we made use of the international data and the compendium giving the frequencies for each possible answer, as well as the score for every principle scale regarding the performances in reading, mathematics and science. The picture that emerged initially seemed to point to a fairly clear trend, but on extending the evaluation to all four possible answers and considering the missing data (no response) the analysis proved more difficult to manage.

To facilitate the analysis we combined the first two answers and the last two (dichotomization). We also

recalculated all the performance variables using methods already employed in PISA (see below). This dichotomization allowed us, in fact, to assess more precisely whether the linguistic and scientific performances of the 15-year-olds is significantly correlated with the incidence of the variable under study, namely 'sing songs' in early childhood.

A first step was to see whether the nine items included in the question PA03 are correlated to one other, that is to say, whether the prerogatives existed for the question itself to be treated as a factor. We therefore considered the collinearity, or more simply the influence of extraneous variables: first and foremost, the socio-cultural and economic background of the family, in PISA measured using the ESCS index.

A further aim was to investigate the possible connection between the level of schooling of the family and the practice of singing songs in the early life of the child. There are some variables present in the PISA database that illustrate these prerogatives in the parents: the level of study reached by the mother (MISCED) and by the father (FISCED), as well as the highest degree of schooling of both parents (HISCED) and the highest parental education in years (PARED). In the present study, we tried to establish whether the hypothesis that a higher level of schooling, especially in the mother, corresponds to a more frequent practice of singing songs to the child is true or not.

## 2.2. Methodologies

The OECD – PISA survey benefits from the collaboration of a large number of prominent scientists and researchers in the field of learning and education. The methods chosen are the most advanced in the sector. PISA is characterized by the use and practical application of the IRT (Item Response Theory), a theory of probability testing based on the models of Rasch. To determine the estimates and standard errors, a complex weighting procedure was applied to the sample that reproduces the sampling design, while for the actual calculation the bootstrap methods were used with the support of the relative software. The Jackknife or bootstrap methods do not take into account the form of distribution, either for the sample or for the underlying statistical universe. A great number of methods based on classical test theory requires the normality of the distribution in the sample to be established, whereas the methods used in PISA also work with other distributions.

The Rasch methods make it possible to represent the results of the single postulate (based on a series of plausible values) where the personal capacity in terms of probability and the difficulty of every single item are indicated on the same unidimensional scale. The mean of the results for the OECD is standardized at 500 points with a standard deviation of 100 points. The models used in PISA are suitable for carrying out research on a large or medium scale, and do not lend themselves to making statements about individual postulates [12].

In this study, which looks more deeply into certain aspects of the PISA survey, the same analysis methods were used. To assess the results of the various groups of subjects with determined characteristics, the plausible values present in the international database were used. The

<sup>2</sup> In other words, a value resulting from a projection of the PISA sample on the total target of 15-year-old school children. The absolute values show that the questionnaire was given to 106,287 parents, of whom 84,365 replied (79.4%).

estimates and standard errors were calculated using the method of replicate weights, adapting these to the various subgroups considered in the study and respecting the principles of the sampling design of the overall PISA research. The dichotomization of the variable ‘sing songs’ was made on the valid answers, thus obtaining three categories: one for those who did not answer this item (who are nevertheless present in the database because they answered other items and are therefore not part of the missing data) and the two categories regarding the frequency of singing songs.

The internal validity of the PA03 factor was measured by applying simple estimates of correlation (rank, or more precisely Spearman, as we are dealing with ordinal scale variables) between the single variables, measuring the significance in accordance with the PISA methods.

To measure the relation between the results obtained for the ‘sing songs’ variable (ordinal scale in the dichotomized form) and the performances in PISA (continuous interval scale variables), we opted for the Kendall correlation, which does not require linearity or equidistance, nor a high level of scale.

### 2.3. Results

#### Internal validity of the PA03 factor.

The first analysis, performed on the correlations within the PA03 factor, produced results ranging from 0.269 to 0.553: all highly significant values (when dealing with a large number of cases, significance is achieved more readily under the same conditions than in a more limited sample). These correlations are rather satisfactory and one might be inclined to consider the whole of question PA03 (including the nine activities with the child) as a single factor applying an appropriate factor analysis, but this is beyond the scope of this study.

Taking item c) ‘Sing Songs’ alone, the correlation with the other 8 items ranges between 0.289 and 0.454. The highest correlation is with item b): Tell stories. A similar picture can, in any case, be inferred for the correlations between ‘sing songs’ and the other items in question PA03. This can also be seen in the following tables (Figure 2) where some examples are given.

	TELL STORIES RARELY	TELL STORIES OFTEN
SING SONGS RARELY	21.3%	19.5%
SING SONGS OFTEN	9.9%	49.2%
	READ BOOKS RARELY	READ BOOKS OFTEN
SING SONGS RARELY	17.6%	23.2%
SING SONGS OFTEN	11.8%	47.3%
	ALPHABET TOYS RARELY	ALPHABET TOYS OFTEN
SING SONGS RARELY	21.9%	18.9%
SING SONGS OFTEN	15.9%	43.3%

Figure 2. Correlations between ‘sing songs’ and the other items in question PA03

#### Correlations between the PA03 factor and the results in Mathematics, Sciences and Reading comprehension.

The following table (Figure 3) shows students’ performance in relation to the frequency of singing by parents at an early age (standard errors are shown in brackets). As we can see, noting also the standard errors, the difference in performance between those who practice singing at a young age and the others who do not practice it, is statistically significant for all 3 PISA skills.

OECD AVERAGE	NO ANSWER	NEVER OR HARDLY EVER/ ONCE OR TWICE A MONTH	ONCE OR TWICE A WEEK/ EVERY DAY OR ALMOST EVERY DAY
READING COMPREHENSION	466 (4.22)	493.36 (1.67)	509.24 (1.20)
MATHEMATICS	466 (4.40)	495.77 (1.66)	506.94 (1.34)
SCIENCE	476 (4.34)	501.77 (1.70)	516.00 (1.27)

Figure 3. Students’ performance in relation to the frequency of singing by parents at an early age

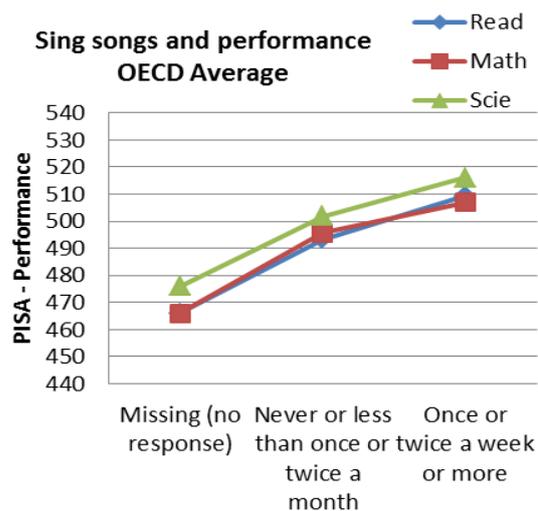


Figure 4. PISA student’s performances in mathematics, science and reading related to the practice of singing songs

Figure 4 shows more clearly that the results obtained by the 15-year-old students in mathematics, science and reading comprehension appear to be proportional to the frequency with which they were exposed to musical-vocal experiences in their early childhood. Note that the distribution of the results is quite the same in the three examined PISA skills (the three curves are overlapping).

The lower PISA scores assigned to those students whose mothers did not answer the question (and clearly involving all three disciplines in a similar fashion) is particularly notable, while equally evident it is the increase in performance – though slightly lower in reading, with 16 points – between the 15-year-olds who benefitted from this musical activity more frequently. In particular, PISA scores of the latter subjects exceed the OECD-PISA international average in all three disciplines investigated, an average that is set at around 500 points.

Moreover, if we take this variable in isolation, the standard errors given in brackets in the table clearly highlight the statistical significance of the differences between those who were exposed to singing in early childhood and those that were not.

It should be kept in mind that the variable ‘sing songs’ relies strongly on the memory of actions carried out by the parents of the students many years before the study. It is therefore difficult to suppose that there could be a causal link between singing in early childhood and the performance in PISA recorded in the teenagers under examination.

On the other hand, it is quite interesting to observe how this variable may represent, together with other similar variables (for example those taken from the other items in the PA03 group), an indicator of the presence of environmental and social factors that positively influence the achievement of appreciable results in the subjects in question (reading, science and mathematics).

First of all, it is necessary to clarify in what way the relation between the variable in question and the PISA performance is influenced by extraneous variables. One possible “disturbing” variable is the ESCS, that is to say, the index of economic, social and cultural status. This index has been set at the value 0 for the OECD mean and standardized at a standard deviation of 1. In the countries where the questionnaire was administered to the parents, the ESCS index takes on a value of -0.2061 with a standard error of 0.004 [13].

Considering once again the dichotomized transformation of the ‘sing songs’ variable as previously explained above, we arrive at the following classification (Figure 5):

	SING SONGS RARELY	SING SONGS OFTEN
Mean of ESCS	-0.2254 (0.006)	-0.1928 (0.005)

Figure 5. Classification of the ESCS indicator related to the frequency of Singing in early childhood

With the help of the respective standard errors, it is easy to deduce that the two values do not deviate significantly from the mean. Calculating the relation between the ‘sing songs’ variable and the performance in PISA, and taking into account the ESCS, the (partial) correlation becomes considerably lower, and the significance disappears for the correlation between “singing songs in the early childhood” and for the

performances in mathematics and science. There remains an extremely small correlation of 0.077 (significantly different from 0) with the performance in reading. The ESCS can be seen to have a notable influence on the correlation between the ‘sing songs’ variable and the performance of the students, even though the socio-economic and cultural status taken alone has no direct significant influence on the ‘sing songs’ variable.

Similar results can be obtained by checking the variables regarding the education levels of the family. Below it is a brief summary of the coefficients of partial correlation with the above-mentioned variables (Figure 6):

CORRELATION BETWEEN THE VARIABLE “SING SONG” AND THE PERFORMANCE IN READING (LEVEL OF SIGNIFICANCE)					
R <sub>sp</sub> <sup>3</sup>	0.057 (0.000)	0.067 (0.000)	0.058 (0.000)	0.058 (0.000)	0.056 (0.000)
Checked for	Miscd	Fiscd	Hiscd	Pared	All of these together

R<sub>sp</sub> = Spearman correlation coefficient

Figure 6. Correlation between the variable “sing song” and the performance in reading

It is worth taking a more detailed look at the situation in the individual countries considered in the study, given that a quick glance reveals notable differences between them. We can see, for example, that the difference in scores between the students who had little or no opportunity to sing with their parents and those that had a considerable amount is 36 in New Zealand and 34 in Chile, whereas in Lithuania it is -3.

### 2.4. Discussion

The international data in our possession do not allow us to offer a diachronically stable analysis on the relation existing between the practice of singing in early childhood and the performances in reading, science and mathematics of the 15-year-old students. This particular variable can be investigated through the data resulting from the parents’ questionnaire used in the PISA 2009 research. However, the results of the survey present certain problems in terms of the limited size of the sample (the questionnaire was administered in only a few of the countries that had participated in the study), the incomplete response rate and the degree of compliance that may have biased the parents’ answers. And then it is quite likely that the countries participating in the PISA parents survey will change in the future, a fact that makes it even harder today to draw definitive conclusions about the topic investigated.

### 2.5. Conclusions

The research shows that the early practice of singing songs has a positive influence on the student’s school performance in the long run, independently of the parents’ socio-economic and cultural status. The students who had had the benefit of singing songs in their childhood have obtained better results in mathematics, science and reading comprehension than the others.

However, the research also shows that within the countries covered by the PISA research the practice of singing songs is also consistent among middle class

children, not less common than amongst their upper class peers. Children of disadvantaged families still obtain relatively better results if they used to sing compared to the expected outcome of their socio-economic class.

## List of Abbreviations

OECD	Organization for Economic Co-operation and Development.
ESCS	(Index of) Economic, Social and Cultural Status.
PISA	Programme for International Student Assessment.
PA	Parents.
PAQ	Parents Questionnaire.
MISCED	Mother's Index of School Education.
FISCED	Father's Index of School Education.
HISCED	Highest Index of School Education.
PARED	Parents' Index of School Education.
IRT	Item Response Theory.

## References

- [1] Maule, E and Azzolin S., *Suoni e musiche per i piccoli. Educazione sonora integrata per la scuola dell'infanzia*, Erickson, Trento, 2009, 139.
- [2] Levitin, D. J., *Fatti di musica. La scienza di un'ossessione umana*, Codice Edizioni, Torino, 2008, 167.
- [3] Pinker, S., *How the mind works*, Norton, New York, 1997.
- [4] Levitin, D. J., *Fatti di musica. La scienza di un'ossessione umana*. Codice edizioni, Torino, 2008, 168.
- [5] Schön, D., Boyer, M., Moreno, S., Besson, M., Peretz, I. and Kolinsky, R., "Songs as an aid for language acquisition", *Cognition*, 106 (2), 2008, 975-983.
- [6] Peretz, I., "Listen to the brain; a biological perspective on musical emotion", in P.N. Juslin, J.A. Sloboda (eds), *Music and Emotion. Theory and Research*, Oxford University Press, Oxford, 2001.
- [7] Threhub, E.S., "The Developmental origins of musicality", in *Nature Neurosciences*, 6 (7), 2003, 669-673; Nakata, T. and Threhub, S. E., "Infants' responsiveness to maternal speech and singing", in *Infant Behavior & Development*, 27, 2004, 455-464.
- [8] Schön, D., Boyer, M., Moreno, S., Besson, M., Peretz, I. and Kolinsky, R., "Songs as an aid for language acquisition", in *Cognition*, 106 (2), 2008, 975-983.
- [9] Gardiner, M.F., Fox, A., Knowles, F. and Jeffrey, D., "Learned improved by arts training", in *Nature*, 381, 1996, 254.
- [10] Rauscher, F. H. and LeMieux M. T., *Piano, rhythm, and singing instruction improve different aspects of spatial-temporal reasoning in Head Start children*, Poster presented at the "Annual meeting of the Cognitive Neuroscience Society", New York, 2003.
- [11] Rauscher, F.H., "Can Music Instruction Affect Children's Cognitive Development?", in *ERIC Clearinghouse on Early Education and Parenting*, University of Illinois, 2003.
- [12] OECD, *PISA Technical Report, Second Edition*, OECD Publishing, Paris, 2008.
- [13] OECD, *PISA 2009 Results. Overcoming Social Background. Equity in Learning Opportunities and Outcomes, Vol. II*, OECD Publishing, Paris, 2010.