【論文】

Effect of Choral Singing on Children's Prosocial Behavior: Role of Oxytocin Secretion

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Abstract

Choral singing is usually performed in music classes in elementary schools and has been demonstrated to promote prosocial behavior. The purpose of this study was to investigate whether choral singing has a unique effect on the promotion of prosocial behavior in children and to elucidate the biological mechanism underlying this effect. We investigated the prosocial behavior measured by the dictator game and oxytocin level measured via saliva before and after choral singing. To determine whether there were any unique effects of choral singing on prosocial behavior, we compared it to the effects of a daily lesson task (performing calculations in groups). The results showed that both choral singing and group calculation promoted prosocial behavior and salivary oxytocin levels. In addition, the salivary oxytocin levels after both group activities were positively related to prosocial behavior. These results indicate that the effects of choral singing are not specific and that group activities in general may induce oxytocin secretion, which, in turn, promotes prosocial behavior.

Introduction

Choral singing is a popular musical activity that is incorporated into educational programs in music classes. School students sing various songs, such as school songs, during music classes. In Japan, once a year, a choral singing competition is held in which each class competes. Such activities enable students to be part of a group, to communicate emotions through music, and to gain the opportunity to play in public, which develops their social skills [1]. A few studies that conducted interviews and questionnaire surveys to assess the impact of music education found that participating in group musical activities promoted a sense of team accomplishment [2,3]. In addition, more recent studies have examined the effect of choral singing using social psychology and biological approaches [4-8]. However, the effects of choral singing on the mental and physical development of children and their underlying mechanisms are not well understood. What is the effect of choral singing as an

educational program? How can choral singing contribute to children's social life?

From an evolutionary perspective, music is a social tool that can promote social bonding and prosocial behavior [9]. Choral singing, which is one form of music activity that is usually used in music education, emphasizes the synchronous activity of a group. According to previous studies, choral singing enhances social bonding with group members [8] and promotes human prosocial behavior, especially cooperation behavior within groups of children and adults [5,10]. Good and Russo [5] examined the effect of choral singing on children's cooperative behaviors by using the prisoner's dilemma game and compared choral singing with other activities such as group art. They found that children who engaged in choral singing were more cooperative than others. In addition, choral singing has a positive effect on psychological health, especially the promotion of psychological well-being [4,7,11,12].

Regarding the positive effect of choral singing on social bonding and prosociality, recent studies have attempted to identify the hormonal mechanism underlying choral singing and found that choral singing influences some hormones such as cortisol and oxytocin [4,13]. Among these hormones, oxytocin, which is a neuropeptide synthesized in the hypothalamus and acting as a neuromodulator in the central nervous system [14], has attracted a great deal of attention. Oxytocin plays important roles in many aspects of human prosocial behaviors, such as promoting trust behavior [15,16], allocation behavior [17,18], and cooperation behavior [19,20]. Notably, positive social interactions such as parent-infant communication [21], a massage [22], gossiping with friends [23], others' prosocial signals [24], interactions between participants [25], and people's interactions with their dogs [26] may promote oxytocin secretion.

In previous choral singing studies, researchers measured oxytocin levels in plasma or saliva before and after choral singing and focused on the change in endogenous oxytocin levels from baseline after choral singing [4,6,27]. Although two studies found that oxytocin levels decreased after choral singing [4,13], most studies showed that oxytocin levels increase after choral singing, which means that choral singing may promote oxytocin secretion [6,7,28,29]. Moreover, Good and Russo [29] found that the change in oxytocin level is positively associated with improved mood states. These findings suggest that choral singing is a type of positive social interaction that could promote oxytocin secretion, and oxytocin has a substantial influence on the effect of choral singing on prosocial behavior. However, the hormonal mechanism underlying choral singing in children has not been examined in previous studies.

Although there are sufficient studies that have investigated the effect of choral singing on prosocial behavior and oxytocin as well as the effect of oxytocin on prosocial behavior, no studies have comprehensively examined the relationship among choral singing, prosocial behavior, and oxytocin. Therefore, the present study aims to explore the relationship between choral singing, prosocial behavior, and oxytocin in primary-school children. We measured prosocial behavior using a dictator game (DG) before and after choral singing. The dictator game is an economic game typically used to measure one's prosociality [30-32], in which game participants receive an amount of endowment and have to decide the allocation between themselves and a stranger. We collected saliva before and after choral singing to measure oxytocin levels; this is an approach that has been validated in various past studies [33-35]. Based on previous studies, we proposed the following three hypotheses:

Hypothesis 1: Choral singing promotes prosocial behavior.
Hypothesis 2: Choral singing induces oxytocin secretion.
Hypothesis 3: Oxytocin levels after choral singing are positively associated with prosocial behavior.

Moreover, previous studies examined the specific choral singing effect on oxytocin by comparing different singing conditions [6,13,29]; however, few studies have compared the effect of group activity to demonstrate the unique effect of choral singing.

According to previous studies, in addition to group singing, other group activities also showed a positive effect on one's prosociality and oxytocin secretion [22,36]. Therefore, in this study, we aim to examine whether the effects of choral singing on prosocial behavior and oxytocin are specific by designing a calculation condition as a comparison. The calculation condition is the group activity in which each child solved math problems in the same classroom, which was comparable to the lesson task-like choral singing condition in daily school. We anticipated that it is difficult to mobilize emotions, unlike choral singing. We believe that this comparison allows for the examination of the unique effect of choral singing and its necessity in school education. If the effect of choral singing is specific, we expect that we will not observe any association between solving math problems and prosocial behavior or oxytocin.

Materials and methods

Ethics statement

This study was approved by the Ethics Committee of Tamagawa University, where the study was conducted according to the approved protocol (approved no. TRE18-009), and it met the requirements of the Declaration of Helsinki. Each participant and parent signed an informed consent form before the study.

Participants

One hundred and one elementary school students (43 boys and 58 girls) participated in the experiment. All participants were in the sixth grade, and the average age was 11.5 (standard deviation=0.5, range=11 to 12).

Procedure

One week before the experiment, participants responded to the Social Value Orientation Scale [37]. This scale consists of nine questions regarding the reward distribution that measure participants' prosociality. Based on the results of the questionnaire, participants were categorized into the pro-social, which favors equitable distribution, and the pro-self, which favors the pursuit of self-interest.

On the day of the experiment, the participants were gathered in a large hall for an explanation of the experiment. About 50 children participated in the session, and a total of two sessions were held on different days (first session: n=52, second session: n=49). The experiment's procedure, which is shown in Fig 1, is described below.

First, the participants played a one-shot DG. The DG is a two-person economic game in which one player who is assigned to the role of dictator decides how to allocate 10 monetary units between the two players. The game ends after the dictator's decision. In this study, all participants played the role of the dictator in the DG. After the experiment, the participants were randomly matched with one of their classmates, and their rewards were determined based on the actual decision. Prior to participating in the experiment, participants were told that monetary units could be replaced with stationery after the experiment was completed. They made their decisions alone, and

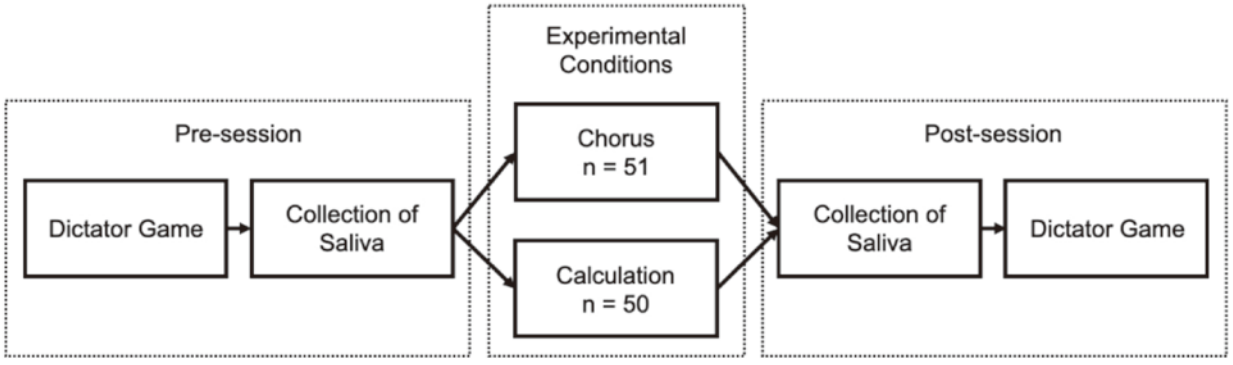

Fig 1. Procedure of the Experiment

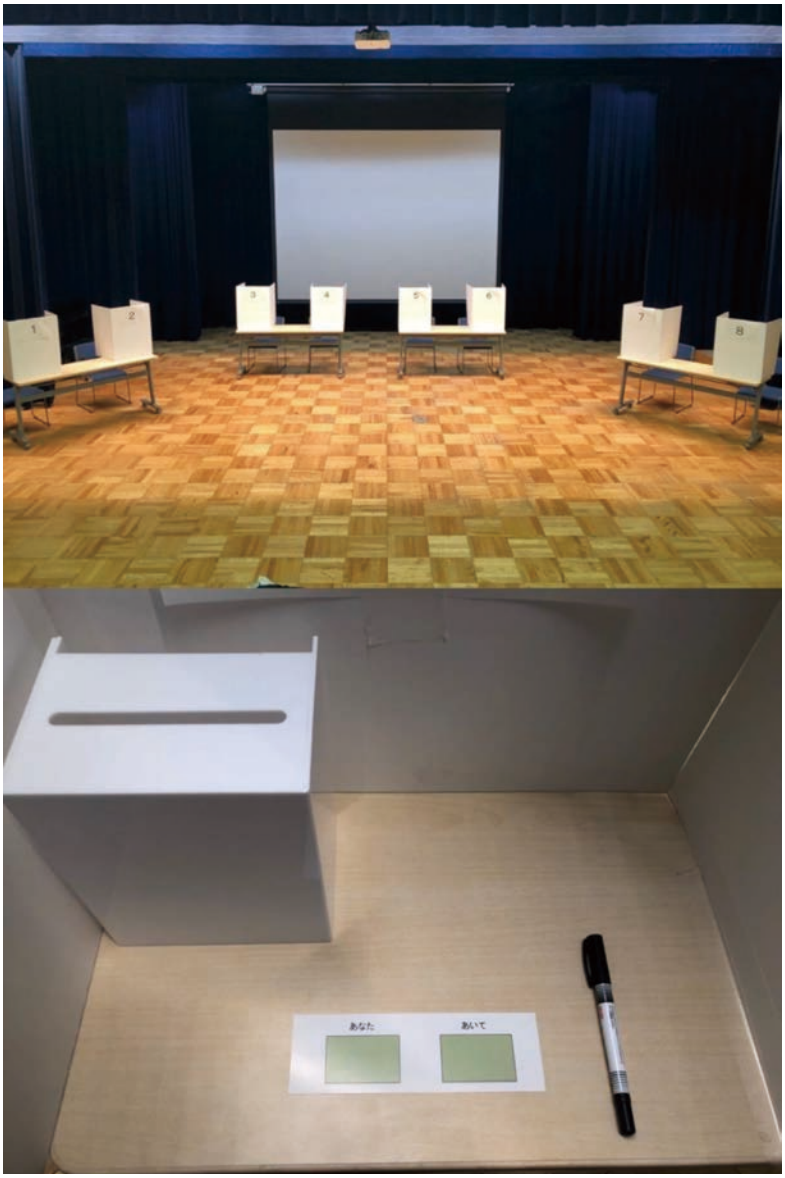

Fig 2. Experimental Setup. Participants played a one-shot dictator game in the isolated compartments where anonymity was guaranteed. It was possible for eight participants to make their decisions at the same time. All participants were asked to play as the dictator and to write an answer on the paper provided. On the paper shown in the picture, the number of monetary units for the self was written in the answer box on the left, and the number of monetary units for the other person was written in the answer box on the right.

complete anonymity was guaranteed (Fig 2).

Second, the participants' saliva was collected using the Saliva Collection Aid device (Salimetrics LLC, Carlsbad, CA, USA). The boys and girls were separated into different rooms for saliva collection. They were required to put a minimum of 1.5 ml of saliva into a vial. A time limit was set for the saliva collection (up to 15 minutes), and the amount of saliva produced within that time was collected.

Third, the participants moved to another classroom and performed the experimental conditions' tasks. Half of them were assigned to the choral singing condition (n=51), and the other half were assigned to the calculation condition (n=50). In the choral singing condition, the music teacher performed the accompaniment on the piano, and the participants sang for 15 minutes. About 25 boys and girls sang in one session. The selected songs were familiar to the participants from their everyday classes. In the calculation condition, the participants performed a mathematical calculation task for 15 minutes. About 25 children participated in one session, and a math

teacher provided them with an explanation. The contents of the calculation task were learned in sixth grade, and the math teacher prepared various problems.

Finally, the participants returned to the hall, performed the saliva collection, and played the DG using the same procedure as above. One session lasted approximately two hours.

Assessment of Salivary Oxytocin

We collected saliva twice: once in the experimental pre-session (before the choral singing or solving math problems) and once post-session. We collected saliva from the participants using the passive drool method. Samples were collected in cryovials and immediately stored at -80℃. Before the assay, we freeze-dried 1 ml of saliva with a freeze dryer (FD-1000; Tokyo Rikakikai Co. Ltd., Tokyo) for approximately 16 hours overnight. The freeze-dried sample was dissolved by adding an assay buffer (using a concentration ratio of four). An enzyme-linked immunosorbent assay was conducted using a commercially available oxytocin kit (Enzo Life Sciences Inc., Farmingdale, NY, USA). The assay was performed in duplicate, and the concentration was calculated using a microplate reader (Sunrise Rainbow RC-R; Tecan Group Ltd., Zürich, Switzerland) according to the relevant standard curves. As 54 children were unable to provide enough saliva (more than 1 ml) for measurement within 15 minutes in each session, we analyzed the hormonal data of 47 children. The intra-assay coefficient of variation was 2.8%.

Statistical analysis

All statistical analyses were conducted using the Statistical Package for Social Science (SPSS) software version 22. Because the participants in this study were children in the same grade, age was not treated as a confounding factor. The significance level for all analyses was set at 0.05.

Results

Social Value Orientation

There was no difference in the proportion of prosocial participants in the choral and calculation conditions (chorus condition=27/51 [52.9%], calculation condition=27/50 [54.0%], $\chi^2(1)=0.01$, $p=.915$).

Dictator's Offer

The mean levels of the dictator's offer for each condition are shown in Table 1. A two-factor analysis of variance was conducted with the timing of the measurement (pre-session DG or post-session DG) as a within-subjects factor of the condition (choral singing or calculation) as a between-subjects factor. The analysis revealed that while the main effect of the timing of the measurement was significant ($F(1, 99)=5.69$, $p=.019$, $\eta_p^2=.054$), the main effect of the condition ($F(1, 99)=0.06$, $p=.807$, $\eta_p^2=.001$) and the interaction effect between the timing of the measurement and the condition ($F(1, 99)=0.27$, $p=.603$, $\eta_p^2=.003$) were not significant.

Table 1 Mean Dictator's Offer Level by Condition

	Choral singing condition (n=51)		Calculation condition (n=50)	
	M	*SD*	*M*	*SD*
Pre-session DG	3.39	3.10	3.16	2.44
Post-session DG	3.73	3.31	3.68	3.03

Note. *M*=mean, *SD*=standard deviation, DG=dictator game.

Salivary Oxytocin Level

The mean levels of salivary oxytocin for each condition are presented in Table 2. The mean level of pre-session sOT was 22.5 pg/ml (SD=13.0), and the mean level of post-session sOT was 28.1 pg/ml (SD=14.1). A two-factor analysis of variance was conducted with the timing of the measurement (pre-session sOT or post-session sOT) as a within-subjects factor and the condition (choral singing or calculation) as a between-subjects factor. The analysis revealed that while the main effect of the timing of the measurement was significant ($F(1, 46)=5.44$, $p=.024$, $\eta_p^2=.106$), the main effect of the condition ($F(1, 46)<0.01$, $p=.998$, $\eta_p^2<.001$) and the interaction effect between the timing of the measurement and the

condition (F(1, 46)<0.02, p=.889, η_p^2<.001) were not significant.

Table 2 Mean Salivary Oxytocin Level by Condition

	Choral singing condition (n=28)		Calculation condition (n=20)	
	M	*SD*	*M*	*SD*
Pre-session sOT	22.4	11.5	22.7	15.2
Post-session sOT	28.3	13.7	27.9	15.0

Note. *M*=mean, *SD*=standard deviation, sOT=salivary oxytocin.

Relationship Between the Dictator's Offer and Salivary Oxytocin Level

First, we investigated the relationship between the pre-session sOT levels and pre-session DG offers. An analysis of covariance was conducted with the condition (choral singing or calculation) as the between-subjects factor, the pre-session sOT level as the covariate, and the pre-session DG offer as the dependent variable. The results showed that there was no main effect of the condition (F(1, 44)=0.1, p=0.753, η_p^2=.002), no main effect of the pre-session sOT level (F(1, 44)=0.03, p=.868, η_p^2=.001), and no interaction effect of the condition and the pre-session sOT level (F(1, 44)=0.04, p=.845, η_p^2=.001). The relationship between the pre-session sOT level and pre-session DG offer is shown in Fig 3A.

Second, we analyzed the relationship between the post-session DG offer and post-session sOT levels. An analysis of covariance was conducted with the condition (choral singing or calculation) as the between-subjects factor, the post-session sOT level as the covariate, and the post-session DG offer as the dependent variable. The analysis showed that while the main effect of the post-session sOT level was significant (F(1, 44)=13.0, p=.001, η_p^2=.228), the main effect of the condition (F(1, 44)=.022, p=.641, η_p^2=.005) and the interaction effect of the condition and post-session sOT level (F(1, 44)<0.01, p=.958, η_p^2<.001) were not significant. The relationship between the post-session sOT level and post-session DG offer is shown in Fig 3B.

Discussion

The current study examined the unique effect of choral singing on prosocial behavior and sOT and investigated the relationship between oxytocin and prosocial behavior in elementary school students. We found that choral singing had a positive effect on promoting prosocial behavior and increasing sOT levels. Moreover, the results showed that the post-session sOT level was associated with post-session prosocial behavior, while the pre-session sOT level was not associated with prosocial behavior in the DG. However, these results were replicated in the

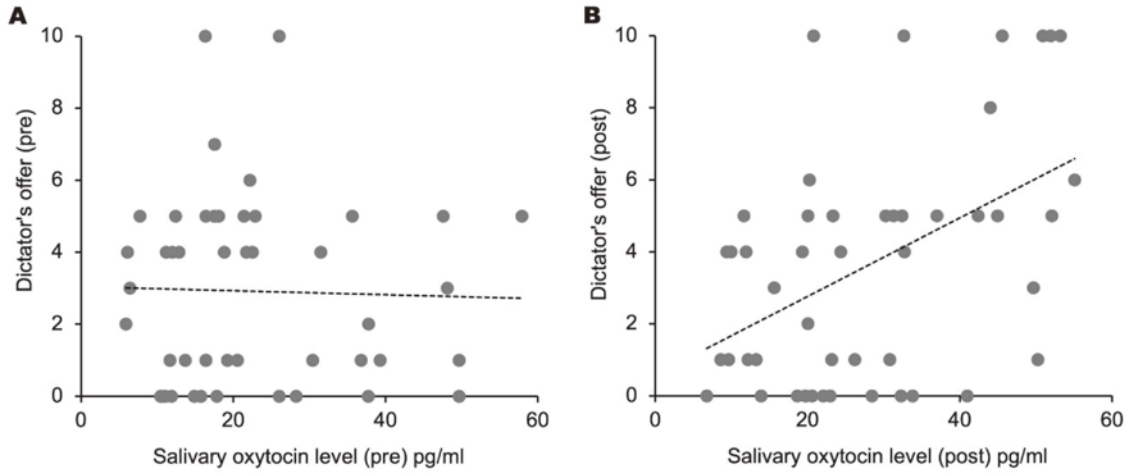

Fig 3. Relationship Between the Salivary Oxytocin Levels and the Dictator's Offer. (A) Pre-salivary oxytocin level and the pre-session dictator's offer. (B) Post-salivary oxytocin level and the post-session dictator's offer. sOT = salivary oxytocin, pre = pre-session, post = post-session.

calculation condition, which means that there is no unique effect of choral singing on prosocial behavior and sOT levels. We evaluated the three hypotheses mentioned in the Introduction. Although these results did not support our hypothesis, our study revealed three important findings.

First, the participants exhibited more prosocial behavior after the group activity than before, although there was no significant difference between the choral singing condition and the calculation condition. The positive effect of choral singing on prosocial behavior shown in this study is consistent with the findings of previous studies [5,10]. To explain these results, it can be assumed that music plays an extremely important role in promoting group cohesion and commitment; therefore, there is increased prosocial in-group behavior and cooperation after choral singing [9]. However, our study's results showed that there was no unique effect of choral singing on prosocial behavior compared to solving math problems, which indicates that choral singing is not the only reason for prosocial behavior being promoted. Some previous studies found that, in addition to choral singing, group activities can also strengthen social bonding and stimulate prosocial behavior [38,39]. Therefore, this study shows that, regardless of the type, group activities themselves can influence prosocial behavior.

Second, we found that the positive effect of group activities increases OT levels. Previous studies have obtained conflicting findings regarding whether choral singing can induce oxytocin release [4,27], and our results provide evidence that choral singing can increase sOT levels. However, our study indicated a lack of the uniqueness of the effect of choral singing on oxytocin compared to other activities, which means that group activities themselves, rather than specific tasks, induce the secretion of oxytocin. One possible explanation for the secretion of oxytocin in the calculation condition is its stress-buffering effect. In addition to interacting with others, oxytocin is also secreted to relieve stress [34,40,41]. Therefore, the calculation task possibly caused stress signals that activated the hypothalamic-pituitary-adrenal axis and oxytocin system. However, the increase in prosocial behavior compared to the before-group calculation implied the positive effect of group calculation on human prosociality, and group calculation promotes oxytocin secretion as a type of positive cue. To identify which mechanism is responsible for oxytocin secretion under calculation conditions and the effect of stress-induced oxytocin secretion on prosocial behavior, it is necessary to measure stress hormones simultaneously.

Finally, the results revealed that the post-session sOT level was positively related to prosocial behavior observed in the DG, regardless of the condition. This study provides evidence that sOT levels before interacting with others in DG are not associated with prosocial behavior, but sOT levels after interacting with others are. Previous studies have demonstrated the positive relationship between social interaction-induced elevated plasma oxytocin levels and prosocial behaviors such as reciprocity behaviors and donations to strangers in adults [22,24,42]. Surprisingly, Zak et al [24] emphasized that oxytocin levels after interaction are associated with prosocial behavior during interaction. In animal experiments, the release of oxytocin could promote the release of ventromedial dopamine [43,44], which is the neurotransmitter involved in the reward system, and it is possible to influence monetary allocation in DG. Therefore, compared to the basal sOT level, the post-activity sOT level is associated with one's prosocial behavior.

The current study initially attempted to examine the hormonal mechanism of the effect of choral singing on prosocial behavior, and several limitations should be taken into consideration. First, this study could not distinguish between the effects of activity contents (i.e., singing or calculation) and group activity on prosocial behavior and oxytocin level. To solve this problem, it will be necessary to have the participants perform the singing and calculation tasks alone and to compare the effect of the specific activities on prosocial behavior and the oxytocin levels to the effect of the group activity of choral singing or calculation. Second, although the positive effect of group activity on prosocial behavior implied that group activity

promotes oxytocin secretion as a type of positive cue, the possibility that oxytocin is secreted because of stress from the group activity has not to be disproven. To identify the underlying mechanism of group activity, future study is necessary to measure stress hormones such as cortisol simultaneously. Moreover, in this study, the participants were from the same school and were grouped by class; thus, they already knew each other. Therefore, it was difficult to examine the effects of group activity on group cohesion. We are considering replicating this experiment with participants who are strangers. In addition, the trial of group activity is limited to 15 minutes in duration; future research should consider examining the effect of choral singing education over a period of months.

The instruction time for arts education has been reduced in recent decades by the Organization for Economic Cooperation and Development member countries, including Japan [1]. Although the number of studies on arts education has been increasing, its benefits have not been fully clarified. Music education is one of the most studied areas in art education because musical activities, which involve a variety of children's complex abilities, such as cognitive, emotional, and social skills, are expected to improve these skills. One of its remarkable effects displayed in previous research relates to academic outcomes and intellectual abilities [45-47], which are thought to be observed in personal activities such as playing instruments [48]. These beneficial effects of music education on cognitive abilities are reported to be small in terms of effect size, but they are considered long-lasting [49]. On the other hand, there is another form of musical activity, namely, collaborative activity, such as chorus and ensembles. These musical activities have recently gained attention, and they are becoming the subject of research that employs various psychological and biological approaches [4-6,8,27]. This current study is among a comparatively new series of studies that have assessed the effect of music as a collaborative activity. Although a small number of studies have been conducted on the influence of choral singing on social development, a future meta-analysis will reveal the size of the effect of choral singing compared to other activities as well as how long the effect lasts. Such an overview of the research will enable us to determine the unique effect of choral singing.

A notable element of the current study is the research approach. Empirical studies have revealed a positive relationship between music activities and academic achievement [46,47,50], cognition [45,51], and social skills and behaviors [52]. These previous studies have demonstrated the effect of music education on demographic measures and behaviors by conducting experiments. However, the current study used a new approach to examine the mechanism that underlies how music education promotes prosociality by revealing the hormone function. These findings provide a more specific level of information as well as physiological information about children's prosocial behavioral processes, which enables us to generate more detailed hypotheses of the effect of music education on prosocial behavior. By implementing these informative measurements of children's prosociality, it can be also implied that the impact of music education differs according to how prosociality is measured and what type of activity is compared to music education. Further research is needed to clarify the physiological mechanisms that underlie how various types of education promote children's social skills. By accumulating such research studies that examine the impact of music education on children's prosociality by applying psychological and physiological measures, it might be possible to discuss evidence-based music education and carry out such education in the future.

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