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Social Network Plasticity in Children

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Abstract

Converging evidence demonstrates that social relationships are crucial for healthy development during childhood. Given the high behavioral plasticity in children, in the present work we seek to evaluate whether an intervention including cooperative and mindfulness based activities could improve social relationships in middle-aged children. Thus, the aim of this study is to quantitatively analyze the impact of this kind of intervention on social networking in 6-7 year olds. In a school context, we conducted a three month intervention in a class (experimental group), which involved 24 participants. Another class of 20 children was randomly assigned as control group, which followed the usual school program. Social networks were compared before and after the intervention by means of a questionnaire asking each child to mention which peers they would like to play with, and which they do not. After the intervention, social network analysis showed an increase in the number and diversity of positive links between peers, and a reduction in negative ones. We also found a higher level of integration, indicated by enhanced positive networks where children with many positive connections tended to connect with those with few links, there were also more positive links between genders. This favorable change could reflect an increase in children's awareness of themselves and others, fostering the emergence of collaboration and empathic concern. The methodology used here shows how quantitative methods coming from complexity science can be applied to social systems in order to, for example, promote cooperation and avoid bullying.

Keywords: Social networks, cooperation, behavioral plasticity, children.

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Introduction

Social environments are crucial for human development, which is demonstrated by the predisposition and need to contact others from early stages (e.g., Bowlby, 1969, Spitz, 1965, Vygotsky, 1978). This condition of need for others is associated with a variety of structural and functional mechanisms such as resonance systems, shared neural circuits, and neuroendocrine processes. Emotional resonance between self and other provides the basic mechanism through which empathy later develops (Decety & Meyer, 2008, Kral *et al*., 2017). Empathic concern refers to the affective response which results from the understanding of another's emotional state (e.g., Eisenberg & Eggum, 2009) and is essential for both the creation and long term stability of social bonds (Watt, 2005). Empathic concern is a necessary condition for pro-social motivation (Batson, 2010, Batson & Ahmad, 2001, Batson & Moran, 1999, Rumble, Van Lange, & Parks, 2010). Empathy implies not only cognitive and emotional understanding of others' feelings, but also a capacity for self-regulation (Decety, Michalska, & Akitsuki, 2008) and sharing (Zahavi & Rochat, 2015). Experiencing empathy has been associated with the ability to regulate emotional response (Eisenberg & Fabes, 1992) as this favors the identification of others' circumstances, allowing the awakening of pro-social internal resources (Decety & Meyer, 2008, Engert, Kok, Papassotiriou, Chrousos, & Singer, 2017). In line with this, several investigations have revealed that mindfulness based practices can help improve emotion regulation and attentional focus both in adults (e.g., Garland, Hanley, Goldin, & Gross, 2017, Goldin & Gross, 2010, Xu, Purdon, Seli, & Smilek, 2017) and children (e.g., Flook, Goldberg, Pinger, & Davidson, 2015, Mendelson, Greenberg, Dariotis, Gould, Rhoades, & Leaf, 2010, Schonert Reichl *et al*., 2015). In particular, children show a high behavioral plasticity, an attribute which reflects the capacity for change and adjustment to new conditions. In consonance with this, it has been observed that emotional dysregulation may be related to social difficulties, bullying and victimization (e.g., Camodeca & Goossens, 2005, Menesini & Salmivalli, 2017, Pakaslahti, 2000, Spence, De Young, Toon, & Bond, 2009). Earlier work in children demonstrated that those who showed greater self-regulation and effortful control displayed higher levels of sympathy and pro-social behavior (e.g., Diamond & Lee, 2011, Eisenberg *et al*., 2007, Posner & Rothbart, 2000). Social environment in formal education settings is an important factor that brings about psychological distress in children. For example, bullying and victimization are frequent aggressive problems in schools that are frequently associated with emotion dysregulation (e.g., Camodeca & Goossens, 2005, Jenkins, Demaray, & Tennant, 2017, Menesini & Salmivalli, 2017, Spence *et al*., 2009, Van der Wal, De Wit, & Hirasing 2003, Wang & Eccles, 2012). Social links in children have been evaluated by means of the sociogram, a reliable parameter that estimates the social network of each child in a group (Garaigordobil, 2005, Gutiérrez, 1999, Lozada, Carro, Adamo, & Barclay, 2014a, Lozada, Carro, Kappelmayer, Kelmanovics, Czar, & D 'Adamo, 2017). In this way, social links can be assessed by means of a questionnaire asking each child to say which peers they wanted to play with, and which they did not. When this measure is applied at different moments within a certain group, dynamic social processes can be examined. In addition, as it analyzes social exclusion, this measure could also illustrate relational contexts in which antagonistic relationships might occur within a group. In spite of the fact that positive social networks are crucial for healthy development during childhood, to our knowledge, very little work has demonstrated an improvement in children's social networks after participating in interventions which promote empathic collaboration. This kind of intervention had previously been conducted in school aged children, showing effectiveness in favoring generosity and emotional regulation, while reducing stress levels (Lozada *et al*., 2014a, Lozada, D' Adamo, & Carro, 2014b, Lozada *et al*., 2017). In these interventions, which included mindfulness-based practices and cooperative activities, empathic concern was actively trained and put into practice through caring for others and listening to others' needs. Although empathy was not measured as such, by means of self-report indices, since they were small children, the authors of these studies considered that empathic collaboration was fostered by this kind of intervention (Lozada *et al*., 2014a, b, Lozada *et al*., 2017). Considering the great impact of social relationships on children's wellbeing (e.g., Perry Parrish, Copeland-Linder, Webb, & Sibinga, 2016, Ponzi, Muehlenbein, Geary, & Flinn, 2016) and the behavioral malleability of middle-aged children, in the present work we seek to evaluate social network plasticity in a formal education context. We aim to study whether experiences involving mindfulness-based practices and empathic collaboration (as in Lozada *et al*., 2014a, b) have an impact on social networks in 6-7 year olds. To this end, social network configuration is compared before and after this intervention in both an experimental and a control group. Based on previous evidence, we hypothesize that participation in the program will bring about an increase the number and diversity of positive social links and a decrease in the negative links between children. If favorable changes in the network configuration are observed, this kind of intervention could be applied with a view to improving social dynamics in education contexts.

Materials and Methods

The research was conducted with children aged 6-7. All participants were in good health, and there were no significant differences in body mass index or socioeconomic level. We randomly chose one class as the experimental group, which consisted of 24 participants (62.5 % boys and 37.5 % girls) and another class of 20 children (45% boys and 55% girls) as the control group, which followed the usual school program. Experiments were conducted in accordance with the Helsinki Declaration. The study had been approved by the Clinical Research Ethics Committee: "Comité de Ética en Investigación Clínica (CEIC) Del Centro de Estudios Infectológicos, Dr. Stamboulian, Servicios en Salud", Revision 919-42-2012 Protocol Bar-Alt-01-2012, and by the Province Council of Education, Argentina. All procedures were carried out with adequate understanding and the written consent of parents and school authorities. Parents of both groups were informed what activities their children would be

undertaking in the study. Participants' data were handled under confidential conditions. The intervention was performed once a week in the experimental group for 10 sessions of 60 minutes, while children in the control group attended normal classes. The intervention involved three consecutive stages: mindfulness-based activities, cooperative games, and to close, a time for reflection while sitting in a circle. Three researchers conducted the program together with the class teacher. The first part of each class included mindfulness-based practices (as in Lozada *et al*., 2014a, b, Lozada *et al*., 2017) which involved breathing techniques and tai chi like exercises. We taught participants how to move slowly and consciously, and children had to focus on each movement, change of posture and synchronization with the others in the group. During the mindfulness based guided breathing exercises, children kept their eyes closed and concentrated on each breath, perceiving inhalation and exhalation, and counting breaths quietly. We started with 2-3 minutes of these exercises and then extended the time gradually. During the second stage, children performed dyadic and group activities which favored empathic concern and prosociality. Children were invited to play and achieve group goals requiring collaboration (as in Garaigordobil, 2005). These games had no winners or losers, and children were encouraged to help each other, listen to others' needs, and make decisions in agreement with others, i.e. helping attitudes between peers were fostered. Finally, a reflective instance was propitiated, in which the entire group sat in a circle. During this time, each participant shared their experience, describing how they had felt, if they had felt cared for or neglected. Thus, the children learnt to listen to each other and be aware of others' needs and points of view. At the same stage of the program, i.e., before and after the intervention (which was conducted only in the experimental group), the children from both groups were asked to state their preference for and rejection of play partners in the class. The question the children were asked was: which classmates will you choose as playmates and which will you not? The choice of peers as playmates is a concept associated at this age with reciprocity and pro sociality (Garaigordobil, 2005). Children were allowed to nominate as many peers as they pleased. Both groups completed the final questionnaire within a few days after the last session of the intervention. These data allowed us to construct Positive and Negative sociograms according to the preferences and non-preferences, respectively, indicated by the children, as performed in previous studies (e.g., Garaigordobil, 2005, Gutiérrez,1999, Lozada *et al*., 2014b, Lozada *et al*., 2017). Data analysis of sociograms was performed blind by a researcher. In order to analyze the effect of the intervention on the class group, we diagrammed children's social networks according to the sociograms. Children's networks are graphs G (C, E) composed by the set *C* of children in the class and the set E of links between them. These links can be positive or negative, depending on the type of bond between the children declared in the questionnaire. The sum of links of a node is the degree of a child. Thus, we define two types of Networks: Negative Network (NN) that contains only links from a child (source) who does not want to play with another (target), and, Positive Networks (PN) composed by the links from children who want to play with others (Figure 1). For each kind of network we constructed two temporal graphs: one corresponding to the first evaluation and the other to the second one, which in the case of the experimental group corresponds to the post intervention results. We performed a detailed network analysis at different levels. At (I) macro level, we calculated a set of metrics for the whole network such as the average connectivity per child (k), network density (i.e., how populated by links the network is) and modular structure (i.e., number of groups communities or clusters of children more connected between them than with the rest of the class), computed using the algorithm proposed by Blondel, Guillaume, Lambiotte, & Lefebvre (2008). We also performed analysis at (ii) meso level, computing the correlation between children's connectivity. We used the degree assortativity, r, as the measure that captures these correlations (Newman, 2002). Thus, in the scenario of symmetric connection (undirected network, i.e., preference/rejection without direction), if densely connected children are connected to children with many connections, the social network is considered assortative, $r > 0$. On the other hand, if densely connected children are connected with poorly connected ones, the network is disassortative, $r < 0$. If no correlation is observed, $r \simeq 0$, this indicates that children do not have link preferences. In the asymmetric connection scenario (directed networks, i.e., there is a source and a target for preference/rejection) we analyzed all the 125 classes of degree assortativity: r (in, in), r (out, in), r (in, out), r (out, out), where the first element in brackets indicates the degree of the source node, and the second, the degree of the target node. We also computed correlation between children attributes, such as their gender. Thus, if boys prefer boys and girls prefer girls, the social network is assortative for this attribute. Therefore, if more empathic concern and pro-socialness are observed, significant changes in the number of positive links will be expected, i.e., a higher number of positive connections and lower number of negative ones after the intervention, as well as a decrease in the density of NNs and an increase in density of PNs. Moreover, we hypothesize that the parameter related to the number of communities will increase for NNs. Thus, negative links would be more confined to groups, not "invading" the network. We also expected to find a decrease in the degree of assortativity in PNs (i.e., the networks tend to be disassortative). The scenario of children with many positive connections connected with similar ones (and vice-versa, children with few positive links connected to those with few positive links) should become dissasortative and then, children with many/few positive connections should be connected most probably with those with few/many links. These changes will also be observed in relation to positive interactions between children of different genders.

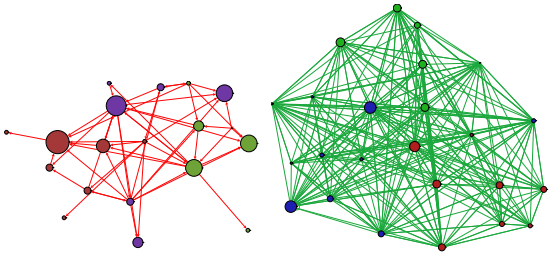

Figure 1: Children's Networks. Negative Network (left) and Positive Network (right) of the two groups analyzed. Notice that the links are directed and the node size represents the in degree. Node color represents the community they belong to.

Results

Macro Analysis

We performed an analysis on the structure of connections for each class of network (PNs and NNs). Results are plotted in Figure 2, with NN on the left and PN on the right. Two sections are plotted for each network: the control group (left) and the experimental group (right). For each group we plotted the topological parameters before and after the intervention. We can observe that in the case of average connectivity (top plot of Figure 2), k, in NNs, this number is higher in the control group at the second evaluation. In contrast, in the experimental group the average connectivity is lower after the intervention. In the case of PNs we can see that the number of positive links increases in both groups but in the experimental group this increment is notably higher. Network density follows a similar pattern (mid plot of Figure 2). The control group's NN is more "populated" with negative links in the second evaluation, whereas the opposite occurs in the NN of the experimental group. On the other hand, in the PN scenario, the population of positive links increases to a much greater extent in the experimental group than in the control group. The community structure of the networks shows that the control group in the NN scenario displayed a drop in both measures (bottom plot of Figure 2). This means that in the second evaluation, negative links in the control group are less confined than before, "spreading out" on the network. The opposite occurs in the experimental group, where after the intervention, negative links seem to be confined within communities (there are more communities). The same is observed in the case of the experimental group's PN. No change in the number of communities is observed in PN of the control group.

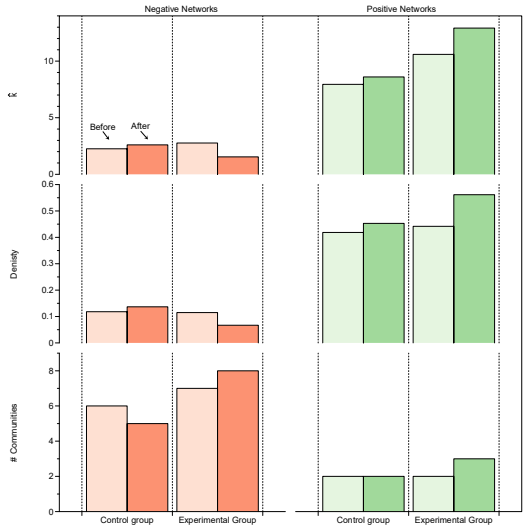

Figure 2: Network properties. Number of communities (bottom), density (mid) and mean degree (top) of control and experimental groups for Negative (left) and Positive Networks (right), before and after the intervention.

Meso Analysis

As in the case of the previous analysis, we computed a set of metrics that capture properties of the interactions at meso level: child to child. We calculated correlations between children's connectivity for undirected and directed scenarios, and also the gender correlation of these interactions. Figure 3 (bottom) shows the values of network assortativity in the undirected scenario for PN in the cases of both control and experimental groups before and after the intervention. As can be seen, no change was observed in the control group, and in both cases, before and after, networks were disassortative, i.e., children with many/few positive connections tended to choose those with few/many links. However, in the experimental group a change was observed after the intervention: PN, having been assortative, became disassortative, i.e., children with many/few positive connections tended to connect with those with few/many links. This may suggest some development of empathy on the part of the most frequently

chosen children. The effect of the intervention on social integration can also be observed in the correlation analysis for directed networks. In the case of r (out, in) we found no change in the control group at the second evaluation (Figure 3, mid).

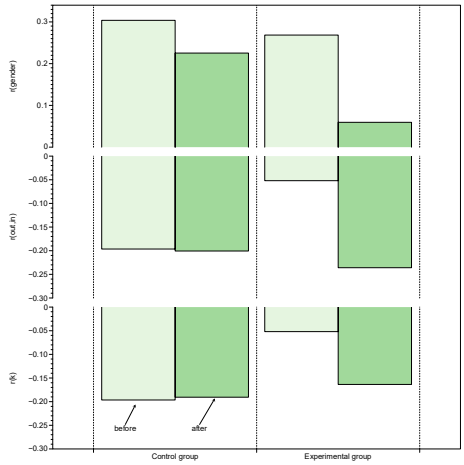

Figure 3: Assortativity in PNs. Degree-degree assortativity r (k) (bottom), out in degree assortativity r (out, in) (mid) and gender assortativity r (gender) (top) for control group (left) and experimental group (right).

The control group's PN remained disassortative. However, the experimental group's PN changed from uncorrelated to disassortative, suggesting the integration of children with few positive elections. A similar integration pattern was observed in the case of gender correlation (Figure 3, top). We observed that in the case of the control group, boys chose boys and girls chose girls, throughout the study. However, in the experimental group the initial disassortative gender preference is lost after the intervention.

Discussion

The present study illustrates young children's great plasticity in relation to their social network configuration as a consequence of experiencing mindfulness based and collaborative activities in a formal educational context. The short intervention modulated social interactions among peers, significantly enhancing positive networks while reducing negative ones. The performed activities provided the opportunity to increase awareness of themselves and of others, fostering the emergence of empathic concern and cooperation. This was reflected in a favorable change in participants' social network configuration. Following the intervention, the network structure analyses showed an increase in the diversity of positive links between peers, and a reduction in negative links within the group. The enhancement of positive networks, in which children with many positive connections tended to connect with those with few (and vice versa) as well as more positive interactions between children of different genders, indicates a higher level of integration among peers. This is probably due to the intervention, given that such changes were not observed in the control group. Our results are in line with the proposal that pro-socialness is an embodied and situated human capacity which is markedly influenced by self-awareness and social experience (Lozada, D' Adamo, & Fuentes, 2011). Participation in the intervention fostered greater diversity and complexity of social networks in the experimental group, whereas this tendency was not found in the control group. The degree of connectivity of NNs is lower after the intervention in the experimental group, while in the control group negative links among peers increased. Moreover, the enhancement of positive links of PNs was higher in the experimental group than in the control group. A similar pattern was observed in relation to network density. NN of the experimental group were less populated with negative links after the intervention, whereas in the control group the NN were more populated. Furthermore, the population of positive links in the experimental group's PN increases much more than in the control group. In addition, analysis of the community structure showed that negative links in the experimental group do not invade the network, they are more confined to communities after the intervention. Moreover, in the experimental group after the intervention, PN's are disassortative (i.e. nodes of low degree are more likely to connect with nodes of a high degree), indicating higher integration levels, this was not observed in the control group. A similar pattern of integration was observed in the case of gender correlation. We found that in the experimental group the original preference of boys choosing boys, and girls choosing girls was lost after the intervention, whereas in the control group this preference was maintained. During childhood, children tend to prefer same-gender play partners, and this tendency, described as emergence of gender or sex segregation, has been explained as a consequence of early socialization through play (Menesini & Salmivalli, 2017, Salmivalli, 2010, Salmivalli, Garandeau, & Veenstra, 2012, Salmivalli, Lagerspetz, Björkqvist, Österman, & Kaukiainen, 1996). This leads to certain polarization within the class, as observed in the control group throughout the study and in the experimental group before the intervention. Our findings demonstrate children's plasticity in their social networks, promoted by the intervention, supporting our hypothesis that

participation in the program would bring about a positive change in social group dynamics. This type of intervention could contribute to a reduction in negative interactions, such as bullying or other conflictive relational patterns. It has been found that negative actions towards a child, (e.g., bullying) implicate most of their peers, with few of them remaining uninvolved (Juvonen & Galvan, 2008, Menesini & Salmivalli, 2017, Prentice, 2008). Therefore, it has been recommended that interventions at the peer-group level, which could influence the whole class context, might be more useful than working with individuals (bullies or victims) (Menesini & Salmivalli, 2017, Salmivalli *et al*., 2012). In line with this, our results showed that the intervention allowed the emergence of more positive networks, as well as an increase in social network heterogeneity, suggesting the positive impact of working not only with individuals but also at group level. This could have helped diminish the so called pluralistic ignorance, a key factor to work with when dealing with bullying (Salmivalli *et al*., 1996). It is likely that mindfulness-based experiences and cooperative playing in which empathic concern, caring and listening to others' needs was actively trained and put into practice, might have promoted new social interaction patterns. Interestingly, cooperative game rules implied that children had to play with peers chosen by chance, enabling social interchanges with non-preferred schoolmates. This might have provided an opportunity to interact in a different way, breaking certain social patterns within the group. Our study showed that after the intervention the network configuration became more open, with a greater diversity of interactions, suggested by a higher number of communities that included more children. This integration process, evidenced by an increase in the positive elections of children who previously had few positive elections, and by mutual positive elections between girls and boys, might be associated with an increase in empathic concern. As the intervention progressed, children mentioned that they felt increasingly well cared for by their peers during the cooperative games, suggesting greater empathic. It has been proposed that higher levels of empathic concern in schoolchildren tend to prevent bullying and other anti-social behavior in formal education settings (Menesini & Salmavalli, 2017, Salmivalli, 2010). Our findings tie in well with previous research in which a similar intervention positively changed children's attitudes towards peers, indicating pro-socialness enhancement, where generosity was also increased (evaluated under anonymity) and aggression decreased (Lozada *et al*., 2014b, Lozada *et al*., 2017). Moreover, social connectedness increased emotional regulation, while stress levels were significantly reduced (Lozada *et al*, 2014a). Earlier studies observed that emotional dysregulation is an important factor correlated with social maladjustment (Eisenberg & Fabes, 1992, Juvonen & Galvan, 2008, Loeber & Coie, 2001, Murphy & Eisenberg, 1997, Pakaslahti, 2000) and peer victimization processes (Camodeca & Goossens, 2005, Spence *et al*., 2009) which produce anxiety, depression, and poor academic performance (Juvonen & Galvan, 2008, Salmivalli *et al*., 2012). Therefore, it is expected that when children are able to regulate their emotions, negative interactions will diminish. A previous study showed that the mindfulness-based practices carried out during the intervention were successfully incorporated by the children, who performed these activities in their homes, mainly when suffering negative emotional states, even five months after the study had finished (Lozada *et al*., 2014a). Most of the participants mentioned having drawn upon these practices when frightened, anguished, angry, in pain, when trying to sleep, to regulate aggressive emotions, or to settle down. Therefore, we hypothesize that this type of practice could help decrease the occurrence of bullying or other antagonistic behaviors in a classroom context. Moreover, as some of the mindfulness based practices involved synchronic movements between children, this could have promoted pro socialness, given that it has been found that children who move in synchrony are more likely to display prosocial behaviors (Cirelli, Einarson, & Trainor, 2014). Other studies conducted on 6-7 year olds have demonstrated that a one-year program of cooperative play for 90 min per week also enhanced pro-socialness (Garaigordobil, 2005). This suggests that the experience of playing in a collaborative way favors positive relationships among peers. Interestingly, in our research we also achieved higher levels of empathic concern and pro-social behavior even though our intervention was much shorter (with significantly fewer sessions). The difference between their study and ours is that our intervention included not only cooperative games but also mindfulness-based practices which helped enhance emotional regulation and interoception in children. Particularly, it was demonstrated that interoceptive awareness, i.e., the process of assessing internal body states) can foster cognitive and affective empathy (e.g., Ernst, Northoff, Böker, Seifritz, & Grimm, 2013, Grynberg & Pollatos, 2015). This could indicate that performing this type of activity might have potentiated the positive effects of cooperative play at this age, highlighting the importance of working both at individual and group levels. One potential limitation of the present research might be related to the fact that we carried out the intervention with one school grade, in order to analyze the group of children who interact together. Therefore, we could not randomize the selection of children included in the class. Another potential limitation could be associated with the fact that children of the group continued with normal classes and did not carry out an alternative activity. Nevertheless, in an earlier study, we observed no significant changes in a control group which performed alternative activities (Lozada *et al*., 2014b). In sum, our findings reveal that enacting the proposed intervention can improve social network configuration in school-aged children. The methodology used here shows how quantitative methods coming from complexity science can be applied to social systems in order to, for example, promote cooperation and avoid bullying.

Conclusion

The current investigation demonstrates that mindfulness-based practices and collaborative activities, which enhance self-awareness and empathic concern performed in a school setting, can increase the quality and diversity of positive networks, while decreasing negative interactions between classmates, thus reducing the probability of antagonistic interactions. Given that childhood is a period of life which is highly sensitive to a variety of stressors, and where social

interactions play a predominant role (Hamer, Stamatakis, & Mishra, 2009, Perry Parrish *et al*., 2016, Ponzi *et al*., 2016, Prentice, 2008), the implementation of practical tools that increase social well-being are particularly significant. Consequently, the application of similar practices in formal education contexts might help reduce distress and suffering in early life, favoring the emergence of long term healthier connectedness. The present findings provide further support for our hypothesis proposing the intrinsic beneficial effects of pro-social behavior (Lozada *et al*., 2011, Lozada *et al*, 2014a, b, Lozada *et al*., 2017). Overall, the current research emphasizes the usefulness of promoting this type of experience at the present time, given that high levels of aggressive behavior are frequently observed in educational settings and in society in general.

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