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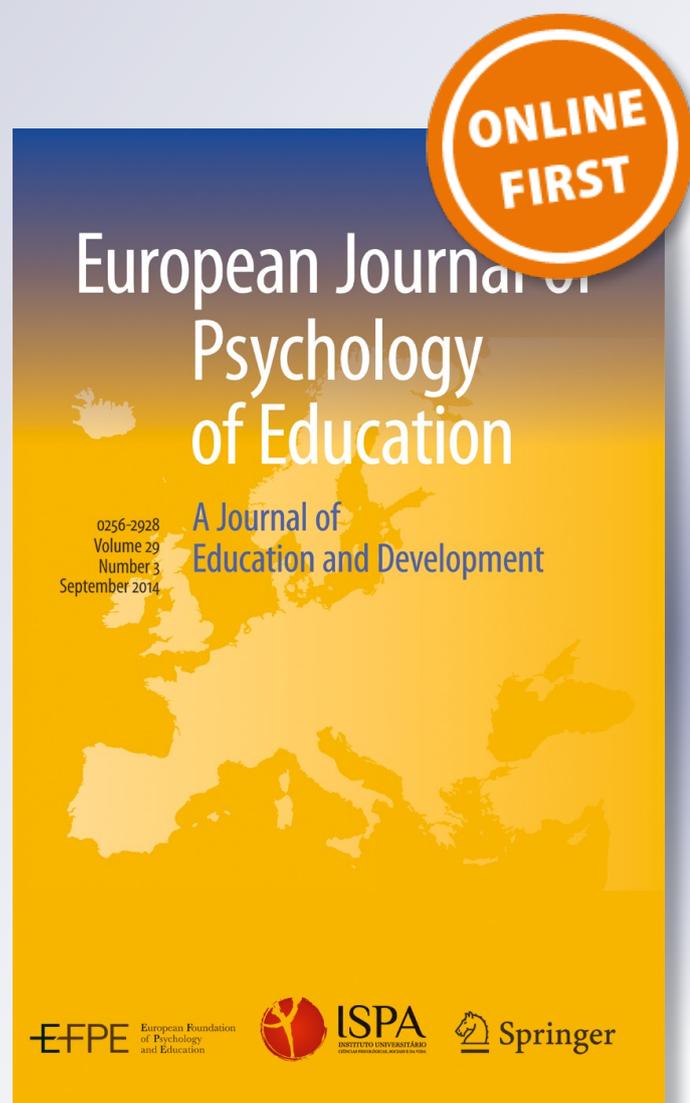
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Peer collaboration in childhood according to age, socioeconomic context and task

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Abstract From a socio-constructivist approach, this work aimed to analyze the characteristics of peer collaboration in dyads of children according to age (4, 8, and 12 years old), socioeconomic context (advantaged socioeconomic context and disadvantaged socioeconomic context), and task (block construction task and free drawing). Eighty-two children (41 dyads) completed both collaborative tasks. Interaction was videotaped and transcribed in terms of verbal and non-verbal behaviors. Interaction was analyzed by a system of exhaustive and mutually exclusionary socio-behavioral categories. The results suggested that age group and task were related to the main differences in peer collaboration. On one hand, dissociation was a typical scene of 4-year-old dyads, whereas the more socially integrated categories, i.e., Implicit Cooperation, Explicit Cooperation, Collaboration and Conversation Related to Task without Execution, prevailed at 8 and 12 years old. On the other hand, differences associated with the task were referred with codes of higher social coordination. That is, the categories that not necessarily imply a distribution of functions on the basis of an oral agreement predominated in block construction task, as occurred in implicit cooperation and collaboration. In contrast, categories of verbal social regulation of roles (explicit cooperation or conversation related to task without execution) predominated in free drawing. Socioeconomic context influenced on fewer categories compared to the age group and task. The findings are discussed in terms of its developmental and contextual implications, and above all, in relation to the socio-behavioral level (regulated by verbalization) of collaborative interaction.

Keywords Peer collaboration · Collaborative learning · Developmental psychology · Socioeconomic context · Task · Childhood

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Introduction

The concept of development refers to qualitative and quantitative changes that allow the child to solve every day problems more effectively. In this sense, the child relies on resources provided by people in social interactions and cultural artifacts which mediate with these social interactions (Rogoff 1990, 2012). This process occurs in specific interactive scenarios, specially, child–adult interaction and peer interaction.

Child–adult interaction (mainly with parents) is distinctly asymmetric since the adult brings the element of cultural significance in interaction and guides the child in the learning process (Ricaud-Droisy and Zaouche-Gaudron 2003). When the child comes into the formal education system, that relationship model with adults is transferred to the teacher–student relationship (Rojas-Drummond et al. 2001). Moreover, the interaction with other children, particularly with peers, is a later social scenario which coincides with an extension of interactions outside the primary family group. In this sense, the child's entry to the formal education system is a very relevant developmental event. Peer interaction is different to interaction with adults because the first one requires a symmetrical contribution which implies an equal participation in the negotiation of meanings. Piaget (1932/1984) emphasized the distinction between child–adult interaction and peer interaction. However, differently to sociocultural perspective, he understands that the child–adult interaction is a relation of constraint because of cognitive dominance of the adult. That relational way is clearly opposed to cooperation because the second one refers to the possibility of a cognitive and social opening, and supposes a symmetric coordination of points of view.

The current investigation focused on peer interaction, specifically, in peer collaboration, as the socio-cognitive process by which two children of similar age work together on a collective task (Fawcett and Garton 2005). Early research about peer collaboration exclusively focused on measuring individual cognitive progress derived from social interaction. Main examples are the investigations of Interactive Paradigm of Intelligence (Doise and Mugny 1984; Perret Clermont 1980), which is based on a Piagetian perspective. Next, especially from the theoretical and methodological critique given by Perret Clermont (Perret Clermont et al. 1991), this approach incorporated the microanalysis of socio-cognitive process. More recently, a third generation of studies focused on the systematic articulation of Doise's (1986) four levels of analysis in the study of cognitive development: intrapersonal, interpersonal, intergroup/positional, and ideological/social representational levels (Psaltis et al. 2009). These studies incorporated the analysis of social factors, social representations, and social categorizations, such as gender, ethnic origin, popularity, academic reputation, social influence, and social class (e.g., Leman and Björnberg 2010; Leman et al. 2010; Psaltis and Duveen 2006; Quiamzade 2007; Quiamzade et al. 2003, 2009). According to the distinction among those generations of studies, the current investigation mainly concerns to the second one since it was focused on socio-cognitive aspects of peer collaboration.

Different works identified socio-cognitive interaction types mainly based on the conversational dimension. Early, Piaget (1923/2002) had proposed different conversational modalities between children which follow a developmental trend, from the collective monologue (related to intellectual egocentrism) to social forms of greater integration and abstraction, such as collaboration in abstract thought and genuine argument (both strictly considered as coordination based on mental reversibility). The Theory of Socio-cognitive Conflict (Doise and Mugny 1984; Perret Clermont 1980), although founded on the Piagetian perspective, adopts a critical position since it understands social interaction as the determinant factor of cognitive development, not as a product of individual cognitive structure as Piaget suggested. The concept of socio-cognitive conflict refers to the basic mechanism that explains the influence of social

interaction on cognitive development. The joint production with partners predisposes to a conflict of individual perspectives and the subsequent reorganization in children's thinking. Studies based on this approach are characterized by proposing collaborative tasks performed by two children (in the case of dyads) with opposed perspectives about a solution of a problem. Children were asked to discuss, in order to confront positions and to achieve a new solution.

Psaltis and Duveen (2006, 2007) identified four conversation types with direct links to individual cognitive progress and no progress. They analyzed 6- and 7-year-old dyads integrated by a conserver and a non-conserver. Children performed the classic Piagetian task of conservation of liquid. One of those conversational patterns, explicit recognition, is directly linked to cognitive progress since the non-conserver actively builds a conservative solution and gives some explicit recognition of conservation within the conversation itself. Two other conversation types, non-conserving (where the non-conserver persuades the conserver) and no resistance (where the non-conserver passively accepts the conserving argument of the partner without stating his own point of view), are asymmetrical interactive forms because one subject imposes a perspective to the other one, without a valid shared construction of the solution. Finally, there is also a last conversational mode, resistance, where the non-conserver supports a point of view before accepting the argument of the partner. Different from explicit recognition, the last three conversation types are not associated with cognitive progress.

Moreover, Vygotskian approach emphasizes the inter-subjective nature of collaboration (Mercer 1996). The concept of intersubjectivity refers to the process in which two individuals achieve to build a shared field of meaning linked to the resolution of a problem or collective activity (Mortimer and Wertsch 2003; Rogoff 1990, 2012; Tudge 1992). Different socio-cognitive conversational modalities were also identified from this perspective. Forman and Cazden (1985) proposed three interactive forms: (a) parallel form, in which there is no exchange between partners; (b) associative form, in which children share information about the actions of each one, but they do not attempt to coordinate roles in terms of a collective action; and (c) cooperative form, where both children control the partner's action and coordinate social roles for achieving a collective action. The cooperative modality is directly linked to cognitive progress. Similarly, Berkowitz and Gibbs (1983) and subsequently Kruger (1992) and Kruger and Tomasello (1986) used the concept of transactive discussion, which refers to the verbal exchange in which each subject represents and/or actively operates on the reasoning of the partner. Mercer (1995, 1996, 2001) proposed the concept of exploratory talk in which partners achieve an authentic construction of shared meanings based on critical confrontation of perspectives (offering suggestions and alternatives of action). This modality is different from disputative talk and cumulative talk which refer, respectively, to disagreement and individual decision making or to passive and uncritical acceptance of what the partner said.

Generally, Piagetian and Vygotskian previous works identified socio-cognitive interaction modalities based on conversational exchange, proposing tasks that require both resolution and intersubjective coordination mainly at discursive level. However, other collaborative activities were analyzed too, such as tasks that demand both resolution and intersubjective coordination at level of action, either with or without verbalization. Mugny and Doise (1979) and Doise and Mugny (1984) are classic examples of that. They proposed a set of pulleys which require coordination among them in order to move a central part attached by strings along a predetermined path. Each pulley is moved by one child. This task represents an intrinsically collaborative activity because its implementation necessarily involves coordination of individual behaviors without needing of verbal collaborative instruction.

Other physical tasks were analyzed but they were not intrinsically collaborative activities. By contrast, in these tasks (e.g., a block construction task or a puzzle), the coordination of

actions depends on the relationship established by partners. The researcher explicitly asks the children to work together and coordinate their actions. Most of these works emphasized the analysis of verbal dimension, but some of them also included the analysis of individual actions related to interaction. In this sense, Psaltis (2012), Psaltis and Zapiti (2014), and Zapiti and Psaltis (2012) not only applied their four conversation types on the Piagetian village task (originally used by Doise and Mugny 1984), which is a construction task and mostly action based; they analyzed individual specific moves of each partner separately (interruptions and challenges), as forms of behavioral emergence of socio-cognitive conflict. However, the modalities assumed by socio-behavioral collective action (i.e., the quality of social integration of the action at dyadic level) did not studied in depth before. For example, previous authors did not inquire which child built the village (whether it was only one child or two children) or how children socially regulated their actions on the task (distributing individual functions or working together simultaneously). The current investigation studied this kind of issues, which means focusing on the social coordination of actions during the activity.

Arterberry et al. (2007) applied five socio-behavioral patterns on the collaborative resolution of puzzles: (a) Working Independently, defined as on task but not talking with the other person or not sharing; (b) Fighting, defined as raising the voice, grabbing the same pieces, hitting, not sharing, calling names, and/or saying “No”; (c) Competing, defined as bragging and/or comparing each other’s performance on the puzzle or in other areas (such as height or athletic ability); (d) Cooperating, defined as providing help or working together with actions such as showing, pointing, and encouragement; (e) Off Task, defined as when the children were not touching the puzzle, not talking about the puzzle, and looking elsewhere in the room.

Some Arterberry’s categories were adapted for the current investigation, while other codes were constructed ad hoc. In this paper, Working Independently was called Dissociation. Fighting and Competing were unified as Dominance-Submission. Cooperating was divided into three categories: Implicit Cooperation, Explicit Cooperation, and Collaboration. This division was based on current discussion about theoretical distinction between cooperation and collaboration. Although there is not a univocal criterion for distinguishing them, it was proposed that main differentiation could be the division of individual functions in the task (Barkley et al. 2005; Dillenbourg 1999, 2002; Dillenbourg et al. 1996; Roselli, 2007). Cooperative modality refers to two adjacent moments: (a) (spontaneous or verbally agreed) distribution of individual functions and activity of each participant according to their individual role; (b) integration of individual partial works and achievement of a collective production. Instead, collaborative modality involves an integrated process where there is not a previous social division of functions and both children simultaneously work together as a collective subject. Finally, this research proposed two new categories referred to interaction when the action is stopped, either to discuss planning strategies, to reevaluate and correct actions or to regulate social roles (Conversation Related to Task without Execution), or to talk about irrelevant issues (Conversation Unrelated to Task without Execution).

This investigation was carried out from three points of view: according to age group (developmental perspective), socioeconomic context (social perspective), and type of task. In relation to age, three groups were compared: 4, 8, and 12 years old. These age groups were intentionally chosen because they traditionally represent three prototypic stages in the evolution of social coordination (Piaget 1932/1984). According to Piaget (1964/1995), there are also other intermediate ages related to key changes in cognitive development, but the current study specifically focused on the analysis of social development and those intermediate age groups were omitted. For example, following the idea of conservation, the age of 6 could be used in this study; however, attending to development of social coordination, this age is still between an egocentric-constraint social pattern (certainly present at 4 years old) and a cooperative

social pattern (certainly present at 8 years old). Also, three age groups were select because it refers to the introduction (preschool), the middle (third year), and the end (seventh year) of scholar trend in childhood.

The analysis of peer collaboration in different age groups has been performed in several works. Lacasa et al. (1995) compared 5–6 years old (preschool) and 7 years old (second year) dyads in construction tasks with geometric materials. They observed higher symmetry and higher quality communication predominated in the older group. The lower quality interactions (high asymmetry and poor communication) prevailed in younger children. Moreover, they found a low frequency of tutorial scenarios which would indicate children's difficulties at these ages to hold guidance and assistance relations with their partners. Ogden (2000) investigated evolution of reciprocity in 5 to 7 years old pairs in block construction tasks, i.e., the ability to correspond and to provide feedback on the actions and messages of a partner. The older subjects (7 years old, second year) showed reciprocal interventions more significantly compared to 5- and 6-year-old children. There were no significant differences between 5- and 6-year-old children. Garton and Pratt (2001) compared communication patterns in sorting tasks in 4- and 7-year-old dyads. Developmental differences referred to higher use of verbal language (procedures, description about the task and actions, and control of the activity) in 7-year-old dyads compared to 4-year-old dyads.

Socio-constructivist approach understands development is overlapped by the social context. For example, early studies by Mugny and Doise support this idea (Mugny and Doise 1978, 1979; Mugny et al. 1979). They founded initial cognitive differences between children of advantaged and disadvantaged socioeconomic levels; however, after some collaborative experiences, that difference significantly decreased. In this sense, the Genevans considered cognitive differences between socioeconomic levels as related to a lower quantity of socio-cognitive experiences by disadvantaged group (Del Caño 1990). In other words, the relation between cognitive development and social context was explained by a quantitative criteria (higher or lower socio-cognitive opportunities). Complementary, this research examined whether these social differences are associated with differences related to the quality of the socio-relational process, analyzing the characteristics of collaborative process itself.

Also, several studies based on Vygotskian perspective showed a direct link between sociocultural differences and the development of psychological functions (Correa-Chávez et al. 2005; Mejía Arauz et al. 2005, 2007; Morelli et al. 2003; Paradise and Rogoff 2009; Scheuer et al. 2006; Tudge et al. 2006). Other investigations specifically focused on socioeconomic conditions. Salsa (2012, 2013) and Salsa and Peralta (2001, 2009) found significant differences between socioeconomic contexts in regard to the acquisition of symbolic competences in young children. However, the influence of SEC on children's peer collaboration has not received great attention. Therefore, in this article, the analysis of that variable was based on the interest in analyzing the influence of differential access to social and economic conditions, called advantaged socioeconomic context (ASEC) and disadvantaged socioeconomic context (DSEC). Probably, these conditions determine differential effects in regard to the capacity of socio-cognitive collaboration. This not only refers to development of cognitive competences (such as it was demonstrated by contextualized studies of child development), but also to the development of social articulation competence of individual actions.

Finally, tasks that mainly demand both resolution and intersubjective coordination at level of action (either with or without verbalization) were analyzed in this investigation. Furthermore, according to a contextual approach (Lacasa and Herranz 1989), this work compared two collaborative tasks, specifically, a construction of a house using Lego blocks and a free drawing. The criteria used in selecting and designing these activities were as

follows. First, these tasks differ according to the intrinsic restrictions of materials: the construction of a house involves a higher restriction degree because children work with three-dimensional pieces and must consider physical laws for constructing it (e.g., the basis of the house must hold the rest of construction, which implies a proportional relation between these aspects); instead, a free drawing involves a lower restriction degree of materials since children work on a two-dimensional plane (paper) and their graphic production does not necessarily need to be restricted to an objective reference (children can draw whatever they wish). Second, both tasks also differ according to the presence or absence of external model required by the researcher: in the construction task, children are asked specifically to build a house (which requires to solve inherent requirements about what a house and its components are); instead, in the free drawing children have total freedom regarding to the content and realization mode of the graphic, i.e., they do not have to draw an specific model such as it happens in later tasks. In summary, it could be considered that both tasks refer to a higher and lower degree of cognitive accommodation, respectively (Piaget 1964/1995). It should be noted that a pure research design has to include other intermediate combinations, either a free construction task or a drawing of a house. However, the main interest was on comparing the opposite paradigmatic situations according to those possibilities: high intrinsic restrictions of materials with an external required model (construction of the house) and low intrinsic restrictions of materials without an external required model (free drawing).

Task constructions were used in some works to analyze the collaborative process (Azmitia 1988; Holmes-Lonergan 2003; Ogden 2000). Following Azmitia (1988), this type of activity requires representing mental spatial relations, which is an important component of intelligence; it requires breaking down a complex system, which is an important problem solving skill; it is familiar and enjoyable for preschoolers and scholars. Regarding to free drawing, recent studies proposed to extend the analysis of peer collaboration to more open-ended tasks (also called expressive tasks), different from classical problem solving or scientific reasoning tasks (MacDonald et al. 2000, 2002; Miell and McDonald 2000; Rojas Drummond et al. 2008; Roselli 2011; Roselli et al. 2010; Vass et al. 2008). However, the literature does not register the previous works referring to collaborative free drawing. Then, this topic was addressed in an exploratory way. In relation to comparison between current tasks, it was anticipated that they were differentially related to interactional modalities. Although there is a little previous evidence for predicting specific differences (as formal hypothesis), it was expected that the construction of the house (higher restrictions of materials with an external model required by the researcher) was associated to more collective interactional modalities. Instead, it was expected that the free drawing (lower restrictions of material without an external model required by the researcher) was related to interactional modalities of individual imprints (Roselli 2011).

Method

Participants

Eighty-two children (41 dyads) from Rosario (a city in Argentina with a population of nearly a million people) participated in the study. Twenty-six children were from preschool ($M=4.7$; $SD=0.3$; 12 girls and 14 boys), 28 children were from third year ($M=8.7$; $SD=0.3$; 12 girls and 16 boys), and 28 children were from seventh year ($M=12.6$; $SD=0.4$; 10 girls and 18

boys). At the same time, 46 of these participants belonged to ASEC and the other 36 to DSEC (see Table 1).

Dyads were formed according to the following criteria: (a) children of similar age, same class, same gender, and socio-affective mutual affinity should be paired; (b) the sample should be equitably distributed by homogeneous and heterogeneous pairs according to intellectual level of both members. Children with special needs were not included.

Participants of ASEC were from two private schools located in the downtown area of the city, (third and seventh year from one school were included and preschool from the other school. Most of these children lived in urban areas with access to public services (transport, electricity, sewers, natural gas, etc.) and houses or buildings of medium and high economic value. In general, parents of these children were middle or high socioeconomic status. The parents were professionals, teachers, business owners, government employees, and clerks, all of them had completed at least secondary school and in several cases had university education.

Participants of DSEC were from a school located in a very poor and marginal area in the city, where the presence of laying out of the streets was rare (in Argentina this type of slums are called “*villas de emergencia*” or “*villas miseria*”). This group of children lived in those slums and had a low family income. The houses in this type of slums were poorly built. Most of the constructions were done with thin layers of cheap wood and tin. Only a few houses had a bathroom. Parents of these children were mainly occasional workers construction, gardening and carpentry, peddlers, garbage collectors, or unemployed. Only in a few cases parents had a permanent job. Most mothers were housewives, although others worked in domestic service. Most parents had not completed primary school.

Materials

Block construction task

Children of 8 and 12 years old used 500 Lego blocks of different shape, volume, and color. The material also included one door and three windows, each of them with a specific format. Twelve-year-old children also had optional pieces, tiles, for construction of the roof. In turn, 4-year-old children use the same materials than older children but with developmental adaptations. These blocks were larger, more flexible, and lower in number of units (23 blocks) than materials used by 8- and 12-year-old dyads. Four-year-old children also had a model house, which used as a reference for the construction. All developmental adaptations of the materials were performed by an ecological requirement, considering the specific conditions of each age group (Garton and Pratt 2001).

Table 1 Characteristics of participants

	Group age			Total
	4 years old	8 years old	12 years old	
Quantity	26	28	28	82
SEC				
ASEC	14	16	16	46
DSEC	12	12	12	36
Mean of age (SD)	4.7 (0.3)	8.7 (0.3)	12.6 (0.4)	8.8 (3.3)

Free drawing

Materials were similar for different age groups: a white cardboard (63×44 cm), a black pen, six colored pencils, 12 crayons, a pencil sharpener, and an eraser.

Procedure

Initially, all students individually proposed three partners of the same class and gender with whom they would most like working as a team. Subsequently, they individually completed a general intelligence test (for preschool, the Matrices subtest from Kaufman Brief Intelligence Test; for third year, the Raven's Colored Progressive Matrices; and for the seventh year, Raven's Standard Progressive Matrices). Based on both assessments, dyads with socio-affective affinity (mutual choice between its members) were detected first, which were then selected or discarded for the final sample according to a matching criterion in the number of dyads with intellectual homogeneity and heterogeneity. This criterion was determined by whether the individual scores of both children was, respectively, in the same or different percentile range, according to the reference scale (1–4, 5–9, 10–24, 25–49, 50–74, 75–89, 90–94, and 95–99). In general, dyads were integrated by children of medium and high intellectual level, leaving cases of deficient scores out.

Each selected dyad was called out of the classroom during the school day to complete both collaborative tasks. The sequence of performing tasks was counterbalanced. In block construction task, both children should build a house jointly; specifically, children were asked to build a house making their best effort with the given materials. The researcher emphasized the importance of agreement when making decisions. Moreover, in free drawing, both children should make a collective graph in a completely free way, using any of the available materials. The researcher also emphasized the importance of working collectively and agreeing on actions and decisions. In both activities, but only in the case of 8- and 12-year old dyads, it was advised that they had approximately 30 min to complete the task, but this time was flexible to avoid the abrupt ending of the activity. Particularly, in relation to 4-year-old dyads, the researcher had to participate in the interactive situation in both tasks. Adult interaction was necessary since young children could not maintain social interactions without the adult participation in the activity. Therefore, the researcher generated some controlled interventions aimed exclusively to support and to motivate the social activity, without interfering with the cognitive functioning of the dyad. Collaborative interaction in each dyad was videotaped and transcribed in verbal and non-verbal aspects.

Analysis of interaction

A system of mutually exclusive and exhaustive categories was designed for the analysis of interaction. Some codes were adapted from Arterberry et al. (2007) and other categories were constructed ad hoc. It was based on three operational criteria: (a) how many subjects were executing actions on the materials at a given time; (b) to what extent these actions were oriented toward a common and collective final product; and (c) if both subjects were working toward a common product, how the social distribution of functions was regulated, i.e. spontaneously or verbally (see Table 2).

Interaction was analyzed from a molecular perspective, which consisted in segmenting it at regular intervals of time and coding each of these segments according to the predominant social behavior modality in that period of time (Anguera 1997). This molecular analysis was justified since the object of study was a collective behavior, in which individual actions of

Table 2 Interaction categories

	Members of dyad executing actions	Actions oriented to collective production	Social regulation of individual functions	Additional details of category
Dissociation	2	Each child directs actions towards achieving of individual product, non integrated respect to that developed by the partner (two separate productions).	Not applicable	Some additional indicators of dissociation in the child who does not work: no seeing the task; no manipulating materials; showing passive corporal posture (e.g., lying on the table).
	1	One child directs actions towards achieving a single product. The other one does not work on the materials and is indifferent regarding the actions of the partner.		
Dominance-Submission	2	One child monopolizes the execution of the task and coercively adds the other one to this action.	Coercive (a child imposes a social function to the partner).	
	2	One of children directs actions towards achieving a single product. The other one does not work on the materials, but passively participates in collective action (silent observation and sustained attention to the individual activity of the active partner).	Not applicable	Differently to previous code (Dissociation), the passive child does not maintain an attitude of absolute indifference to the task. In other words, this child watches and observes the activity's partner, but does not participate in decision-making or implementation of actions. This pattern of interaction could results from two situations: (a) active child imposes upon the other one an attitude of domain (coercion). Specific actions of coercive subject upon passive child: removing materials used by the partner; interrupting verbalization or action on materials; taking a piece arbitrarily from the partner; (b) a child adopts a passive attitude by own initiative, leaving decisions about task to the partner.
Implicit Cooperation	2	Each child directs actions towards achieving a specific aspect of the task, to then joining both productions and achieving a collective final integration.	Each child spontaneously assumes a specific cooperative function,	A common indicator of spontaneous cooperation is the recurring visual monitoring of each child from what activity's partner, as an alternative coordination mechanism to verbal agreement.

Table 2 (continued)

	Members of dyad executing actions	Actions oriented to collective production	Social regulation of individual functions	Additional details of category
Explicit Cooperation	2	<i>Idem</i>	without a verbal explanation. Each child assumes a specific cooperative function based on a previous verbal agreement.	Social regulation is produced by a verbal agreement between children, or when one of them anticipates a next assumption of a function or role and the partner is agreed with that.
Collaboration	2 (Actions are executed jointly between both children or by one, although in this last case actions are designed for both).	Children direct actions towards achieving a collective product, on the basis of strategies jointly developed by them.	Both children are responsible to jointly and simultaneously solve the same aspect of the task. The conversation can or cannot refer to a social regulation of functions.	Both children equally and symmetrically participate in the resolution of a single aspect of the task. They alternately propose ideas, solutions, suggestions and corrections. Children do not execute actions or stop them in order to discuss about planning strategies, reevaluating and correcting actions or regulating social roles.
Conversation Related to Task without Execution	None	Not applicable	Not applicable.	Children do not execute actions or stop them to talk about irrelevant topics to the task resolution.
Conversation Unrelated to Task without Execution	None	Not applicable	Not applicable.	Children do not execute actions or stop them to talk about irrelevant topics to the task resolution.

participants were blended. The unit of analysis was the social interactional behavior registered predominantly in each regular interval which duration was 10 s. A system based in a 10 s gap was chosen because it allowed a detailed record of changes in socio-behavioral patterns of task execution and facilitated the reliability of coding to have an accurate time reference. All coding was done just by one person. A second observer coded 10 % of randomly selected videos, determining an acceptable degree of intersubjective agreement (percentage agreement=85 %, $\kappa=0.76$). Disagreements were solved by discussion. It was noteworthy that in 4-year-old dyads there were some isolated episodes of interaction with the researcher, as part of ecological requirements of the study in this age group. In order to compare 4, 8, and 12 years old, those intervals in which 4-year-old children interacted with the adult were not considered in the analysis.

Because time tasks were different among dyads, the primary value for each category resulted from the relativization of its absolute frequency (i.e., representative intervals for each code) by the total number of intervals to complete the task. For example, if a dyad took 70 regular intervals with a dissociation category and the task lasted in total 180 regular intervals (30 min), the primary value that corresponded to that category was 0.39 (70/180). Each socio-behavioral category was analyzed independently from the others. Most of distributions have showed a violation of normality assumption ($p<.05$), so almost all of them were transformed by $\text{Log}_{10}(x+1)$. Repeated measures analysis of variance was conducted in order to study the relation among each category and the main variables of study (three age groups \times two SECs \times two tasks). The Bonferroni test was used for analysis post *hoc* of comparison by pairs of ages.

Results

Age groups showed a main effect in relation to Dissociation [$F(2, 35)=51.24, p<.001$]. A significant difference between 4 ($M=0.22, SD=0.16$) and 8 years old ($M=0.32, SD=0.16$) was registered, but not between 8 and 12 years old ($M=0.09, SD=0.16$). An interaction between age group and task in the case of Dominance-Submission was detected [$F(2, 35)=4.37, p<.05$]. That is, at 4 years old, a significantly higher value in construction task was registered ($M=0.60, SD=0.21$) than in free drawing ($M=0.18, SD=0.16$); at 8 years old that difference decreased considerably (construction task $M=0.33, SD=0.20$; free drawing $M=0.33, SD=0.15$); finally, at 12 years old that tendency was reversed, i.e. the value was lower in construction task ($M=0.09, SD=0.02$) than in free drawing ($M=0.71, SD=0.15$).

Regarding to Implicit Cooperation, main effects for age group were observed [$F(2, 35)=11.16, p<.001$], SEC [$F(1, 35)=4.33, p<.05$] and task [$F(1, 35)=9.40, p<.01$]. In relation to age group, 8-year-old children ($M=0.08, SD=0.01$) registered a significant difference compared to 4- ($M=0.01, SD=0.01$) and 12-year-old children ($M=0.03, SD=0.01$). Moreover, children of DSEC ($M=0.05, SD=0.01$) implemented significantly more cooperative implicit patterns than children of ASEC ($M=0.02, SD=0.01$). Also, this category showed a higher value in construction task ($M=0.05, SD=0.01$) compared to free drawing ($M=0.02, SD=0.01$). At the same time, an interaction between age group and SEC was registered [$F(2, 35)=4.65, p<.05$]. In this sense, while at 4 years old this code registered a higher value in ASEC ($M=0.01, SD=0.02$) than in DSEC ($M=0.00, SD=0.02$), in older children that tendency was inverted, i.e. it dominated in DSEC compared to ASEC; this was more accentuated with 8 years old (ASEC $M=0.04, SD=0.01$; DSEC $M=0.12, SD=0.02$) than with 12 years old (ASEC $M=0.03, SD=0.01$; DSEC $M=0.03, SD=0.02$).

Explicit Cooperation registered variations according to age group [$F(2, 35)=16.58, p<.001$] and task [$F(1, 35)=5.71, p<.05$], both considered as main effects. Regarding age

group as children were older, the verbal cooperation value increased. However, a significant difference between 4 ($M=0.03$, $SD=0.02$) and 8 years old ($M=0.10$, $SD=0.02$) was observed, but not between 8 ($M=0.10$, $SD=0.02$) and 12 years old ($M=0.15$, $SD=0.02$). Also, in relation to task, explicit cooperation took precedence significantly in free drawing ($M=0.11$, $SD=0.01$) than in construction task ($M=0.08$, $SD=0.01$).

Collaboration category presented a similar tendency to Explicit Cooperation because age group [$F(2, 35)=8.25$, $p<.01$] and task [$F(1, 35)=12.73$, $p<.01$] showed main effects. Collaboration degree also increased according to age, although a significant difference was recorded from 4 ($M=0.02$, $SD=0.01$) to 8 years old ($M=0.07$, $SD=0.01$), but not from 8 ($M=0.07$, $SD=0.01$) to 12 years old ($M=0.09$, $SD=0.01$). Differently to explicit cooperation, collaboration predominated significantly in task construction ($M=0.08$, $SD=0.01$) compared with free drawing ($M=0.04$, $SD=0.01$).

In Conversation Related to Task Without Execution, a main effect was observed by age group [$F(2, 35)=26.82$, $p<.001$], SEC [$F(1, 35)=18.14$, $p<.001$], and task [$F(1, 35)=9.67$, $p<.01$]. The significant difference according to age was between 4 ($M=0.00$, $SD=0.01$) and 8 years old ($M=0.09$, $SD=0.01$), but not between 8 and 12 years old ($M=0.07$, $SD=0.01$). In relation to SEC, children of ASEC ($M=0.08$, $SD=0.01$) registered a significantly higher value than DSEC group ($M=0.03$, $SD=0.01$). Finally, according to task, this category was significantly dominant in free drawing ($M=0.07$, $SD=0.00$) compared to construction task ($M=0.04$, $SD=0.01$).

Conversation Unrelated to Task Without Execution registered variations according to task [main effect, $F(1, 35)=6.93$, $p<.05$]. This category predominated in free drawing ($M=0.01$, $SD=0.00$) compared to construction task ($M=0.00$, $SD=0.00$). At the same time, an interaction between task and age group was identified [$F(2, 35)=3.49$, $p<.05$]; although values almost were null, the difference favoring free drawing was remarkable at 4 years old (free drawing, $M=0.02$, $SD=0.00$; construction task, $M=0.00$, $SD=0.00$); at 8 years old, there was not difference between both tasks (free drawing, $M=0.00$, $SD=0.00$; construction task, $M=0.00$, $SD=0.00$); finally, at 12 years old that difference favoring free drawing again (free drawing, $M=0.01$, $SD=0.00$; construction task, $M=0.00$, $SD=0.00$).

Discussion

The literature shows that the study of the interaction modalities in collaborative work was done on several occasions. However, in general, the types identified were based on conversational exchange, either in verbal tasks or in mostly action based tasks. The current investigation proposed an analysis of modalities of collaborative socio-behavioral action at dyadic level, which has not been studied in depth previously. Therefore, it was tried to broaden the linguistic perspective from which collaborative interaction was usually studied. Also, these socio-behavioral forms of interaction were analyzed during the activity, proposing an analytic molecular perspective of interaction.

Seven socio-behavioral patterns that can be theoretically classified into three groups were identified. Firstly, Dissociation and Domain-Submission are execution modalities of lower social coordination. Secondly, Implicit Cooperation, Explicit Cooperation, and Collaboration are execution modalities of higher social coordination. Thirdly, Conversation Related to Task without Execution corresponds to a virtual action of thinking that does not involve real execution of action on materials. Apart from those categories, Conversation Unrelated to Task without Execution is an irrelevant cognitive action according to activity. The three category groups involve socio-cognitive

levels of increasing complexity in two senses: (a) from individualistic behaviors to coordinated behaviors and (b) from real coordinated action to mental coordinated action.

According to the results, age group was a highly differentiating factor because generated significant distinctions in most of categories, specifically in the comparison between 4- and 8-year-old children. Dissociation was a typical scene of 4-year-old dyads, whereas more socially integrated patterns, i.e., Implicit Cooperation, Explicit Cooperation, Collaboration, and Conversation Related to Task without Execution, predominated at 8 and 12 years old. That occurred independently the SEC or the task.

Results related to comparison between 4- and 8-year-old children are coherent with the previous works (e.g., Garton and Pratt 2001; Piaget 1923/2002). However, according to the framework used in this article, this difference is not interpreted in terms of an evolution from the egocentrism stage to the social stage, as the original Piagetian perspective was proposed. Differently, a socio-constructivist approach (e.g., Rogoff 2012; Vygotsky 1931/1995) understands that at 4 years old the main communication matrix is basically forged on the relationship with the adult. In this asymmetric relation, the adult brings the cultural meaning of interaction. Consequently, when 4-year-old children participate in a social situation of equal exchange with a peer, they confront a new experience in terms of development. They have rudimentary resources to establish peer intersubjectivity (Holmes-Lonergan 2003; Murphy and Faulkner 2000; Sorsana et al. 2013), but the collaborative empirical setting requires a different social regulation comparing to social regulation with an adult.

In contrast, 8-year-old children are able to establish more effective collaborative peer interactions, because peer relations are part of the child's everyday exchanges (mainly from social experiences of schooling and friendship). In this sense, it is a symmetrical process in which construction of shared meanings is more usual, differently to younger children. At this moment of development, children have the ability to establish effective interactions, both asymmetric exchanges with their parents or teachers and symmetric exchange with peers. This conclusion is also applied to 12-year-old children, who have almost no differences compared with 8-year-old children. This could be mainly explained by the changes from 8 to 12 years old represent a quantitative expansion in the degree of social openness and sophistication of language, but it is not qualitative as occurred from 4 to 8 years old. Although different studies showed differences between 8 and 12 years old in terms of cognitive development (e.g., Piaget 1964/1995), in this study differences between that ages in terms of social coordination development were not observed. From the point of view of language development as a guiding action, 12-year-old children are more advanced than 8-year-old children. However, in collaborative manipulative tasks, the intersubjective coordination capacity lies not only in the linguistic register. This means that, even having more precarious linguistic marks, a younger child can achieve a significant development in terms of concerted social action. In other words, although there is a progressive continuity between action and linguistic representation, the behavioral level of concerted action and the verbal level is somewhat independent from each other (Piaget 1923/2002).

On the other hand, the task showed a differentiating effect which is consistent with the previous studies (Arterberry et al. 2007; Holmes-Lonergan 2003; Iiskala et al. 2011; Lacasa and Herranz 1989; Roselli 2011). However, this conclusion should be taken in a general sense because some analytical categories used in this article were adapted or built ad hoc, making it difficult to draw direct comparisons with the literature. For example, although the distinction between cooperation and collaboration has been proposed in theoretical terms (Barkley et al. 2005; Dillenbourg 1999, 2002; Palincsar and Herrenkohl 2002; Roselli 2011), there are no

antecedents where such distinction has been translated operationally into micro-analytical categories.

The difference generated by the task referred to the codes of higher social coordination. The categories that not necessarily imply a distribution of functions on the basis of an oral agreement predominated in the block construction task (Implicit Cooperation and Collaboration). In contrast, the category that implies a social regulation based on division of individual roles which were verbally agreed upon (Explicit Cooperation), predominated in free drawing. In the construction of the house, children were asked to construct a specific object (a house); instead, in free drawing children could draw what they wanted and in the way they wished. In the latter case is probable that needing to decide collectively the content and the way to do the graphic has also demanded a verbal agreement of the distribution of individual functions. In contrast, in the construction task, initial specification of a particular object (house) invited children to engage directly with the action, which would facilitate coordinated spontaneous behavior, without needing verbal mediation aimed at dividing social functions. In this case, each child spontaneously takes care of a part of the building (Implicit Cooperation) or both children work together in the same part of house (Collaboration). The implicit–explicit distinction exclusively refers to social regulation modality of action, i.e., if the distribution of roles occurs in a spontaneous way (without verbal mediation) or based on a linguistic agreement. This direction differs from that proposed by Psaltis and Duveen (2006, 2007) because they referred to social-cognitive process of mental restructuring and this research applied this distinction to the analysis of social regulation of the activity. The category of Conversation Related to Task without Execution predominated in the free drawing. This could be due to the unstructured and free character of such activity, which requires stopping action to coordinate aspects referred to the *modus operandi* of task execution (planning, division of roles, and evaluation of actions).

The SEC influenced on fewer categories compared to the age group and task. This could be because the categories refer to socio-behavioral patterns that can or cannot be accompanied by verbalization. This finding is consistent with the previous studies that suggest that the impact of the SEC is specifically given on language development (e.g., Salsa 2012, 2013; Salsa and Peralta, 2001, 2009). Such differences between SEC would refer to a richer linguistic environment and more elaborated teaching strategies in ASEC rather than DSEC. In relation to peer collaboration, differences are related mainly to semiotic mediation of collaborative interaction, but not in relation to socio-behavioral patterns analyzed in this paper.

There are several limitations in the current study. Although the number of participants analyzed was acceptable, the sample is not statistically representative. This limitation is understandable since the microanalytical study of collaborative process involves a complex collection of information along an appreciable temporal sequence, both as manipulative actions and verbalizations. The density of the data would not be possible if a large number of participants were included. Also, the study was focused on two specific tasks of materials manipulation, by which it could consider new investigations related to other tasks or activities. Furthermore, the research was an observational study in which the researcher always tried to maintain a relative neutral position, in order to ensure control of subjective aspects. However, it is possible to propose a device for future studies that intentionally involves the researcher as a social actor system generated by him as some authors propose (e.g., Álvarez and del Río 1994).

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