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RESEARCH ARTICLE

Collaborative Resolution of Logical Problems in Symmetry and Cognitive Asymmetry Conditions

Resolución colaborativa de problemas lógicos en condiciones de simetría y asimetría cognitiva

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Summary

The article aims to study the verbal collaborative interaction in both symmetrical and asymmetrical dyads according to specific individual cognitive competence. The interaction was analyzed in terms of cognitive and non-cognitive aspects. 19 dyads (38 fifth and sixth graders) participated. First, they individually solve a set of logical problems to determine the initial level of competence. According to the outcomes, symmetric (both subjects of low level of competence) and asymmetric (one subject of low level of competence with one subject of high level of competence) dyads were made up. Second, they collaboratively resolved an equivalent set of problems. The collaborative interaction of the dyads was analyzed by a system of categories of three inclusive levels: (1) if messages were cognitive or non-cognitive; (2) it they were also affirmations, questions or answers; (3) if both cognitive affirmations and answers (both cognitive) were argumentative or non-argumentative. General outcomes showed that the asymmetry of epistemic competence was related to disequilibrium in the amount of messages and cognitive affirmations, especially argumentative, (but not in the rest of categories) in favor of the individual of higher level of competence. On other hand, symmetrical dyads showed equitable interactions related to all categories. A complementary analysis which consisted in an identification of more specific case differences related to modalities of interaction showed specific types of dyads within the general tendencies mentioned.

Keywords: Socio-cognitive interaction, epistemic competence, symmetry, asymmetry, collaborative learning.

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Resumen

Se estudió la interacción verbal colaborativa en díadas simétricas y asimétricas desde el punto de vista de la competencia cognitiva específica individual. La interacción fue analizada tanto en sus aspectos cognitivos como no-cognitivos. Participaron 19 díadas (38 sujetos) de quinto y sexto grado de escolaridad primaria. En una primera fase los sujetos resolvieron individualmente una serie de problemas lógicos, con el fin de determinar el nivel de competencia inicial. En función de los resultados, se conformaron díadas simétricas (ambos sujetos de baja competencia) y asimétricas (un sujeto de baja competencia con un sujeto de alta competencia), las cuales, en una segunda fase, resolvieron colaborativamente una serie equivalente de problemas. La interacción colaborativa de las díadas se analizó por un sistema categorial de tres niveles inclusivos: (1) si los mensajes eran cognitivos o no-cognitivos; (2) si éstos eran, a su vez, afirmaciones, preguntas o respuestas; (3) si las afirmaciones y respuestas (ambas cognitivas) eran argumentadas o no. Según los resultados generales, la asimetría de competencia epistémica se asoció con un desequilibrio, a favor del sujeto de mayor competencia, en los volúmenes generales de mensajes y de afirmaciones cognitivas, sobre todo argumentadas (no así en el resto de las categorías). En las díadas con simetría de competencia epistémica se observó un intercambio equitativo en todas las categorías. Un análisis complementario, consistente en la identificación de diferenciaciones casuísticas más sutiles relativas a las modalidades de interacción, evidenció tipos diádicos específicos dentro de las tendencias generales señaladas.

Palabras clave: Interacción sociocognitiva, competencia epistémica, simetría, asimetría, aprendizaje colaborativo.

Introduction

The subject matter of this study is the socio-cognitive verbal interaction that takes place in children's collaborative resolution of logical problems in dyads. Specifically, the study is focused on the symmetry or asymmetry of such interaction, in other words, higher or lower equilibrium between partners' individual arguments.

Peer collaboration studies have prioritized the analysis of problem-solving and knowledge learning tasks because generally the basic interest is placed on the relation between interaction and intellectual development (Castellaro & Roselli, 2014; Roselli, 2016). In this sense, this study is inscribed in such purpose, but the analysis is focused on the type of socio-cognitive interaction resulting from the similarity or difference between the levels of competence of the subjects of the analyzed dyads. Other particularity of this approach is the consideration of the non-cognitive aspects of the interaction, making it possible to approach the socio-cognitive elaboration process in a more comprehensive manner.

In the literature, effects of symmetry/asymmetry between dyad peers' competences have been studied with respect to increased individual cognitive performance (e.g. Fawcett & Garton, 2005; Garton & Harvey, 2006; Asterhan, Schwarz & Cohen-Eliyahu, 2014). In general, these studies agree that a moderate difference between the levels of competence of the subjects is linked to increased individual cognitive performance. However, these studies fail to analyze the socio-cognitive interaction, which constitutes a key intervening development explanatory variable.

On the other hand, there are studies which do analyze the influence of the epistemic equality/inequality on socio-cognitive interaction, especially in dyads with competence asymmetry (e.g. Denessen, Veenman, Dobbelsteen & Van Schilt, 2008; Schmitz & Winskel, 2008; Tudge, 1992). These studies present two basic conclusions. The first conclusion refers to the predominance of the most competent subject with respect to cognitive

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aspects of the interaction (e.g. this subject is responsible for most of the cognitive elaboration process). The second conclusion holds that socio-cognitive interaction quality improves when the *distance* between individual competences is moderate (e.g. low-medium) and non-extreme (low-high).

Traditionally, studies on epistemic symmetry/asymmetry effects on interaction prioritized the analysis of cognitive aspects. However, the current aim is to go beyond such cognitivist or epistemic view in order to give way to an approach with more psychosocial and/or social influence aspects (e.g. Leman, 2015; Psaltis, Duveen & Perret Clermont, 2009; Quianzade, Mugny & Butera, 2014; Sorsana & Trognon, 2011). This suggests an improvement of an abstract collaborative perspective, comparable to a networking or multi-agent thinking structure. Instead, in this new approach, coordinating with others suggests a collective thinking situated, in other words, mediatized by the assigned roles and/or mutual representational attributions of the interacting subjects. Precisely, the context idea includes the physical environment of the activity and the other psychosocial factors which mediatize intersubjective collaboration (Psaltis, 2005; Psaltis & Zapiti, 2014; Schwarz, Perret-Clermont, Trognon & Marro, 2008). In line with the above, this study intends not only to make visible the cognitive elements of the interaction, but also other forms of symmetry/asymmetry linked primarily to non-cognitive or social aspects of the interaction.

In this sense, differentiation between an epistemic form and a relational form of conflict resolution (e.g. Buchs, Butera, Mugny & Darnon, 2004; Peralta & Roselli, 2016; Peralta, Roselli & Borgobello, 2012; Quimzade & Mugny, 2001) constitutes an important contribution. This makes it possible to differentiate equitable and argumentative modalities of interaction (in the case of epistemic modality), or modalities based principally on comparison of peers' social position and definitive problem-solving by confrontation or imposition of individual point of view (in the case of relational modality). Also, particular relevance was gained by the studies conducted by Psaltis & Duveen (2006, 2007) and Zapiti & Psaltis (2012), in which they identified

different forms of conflict resolution based principally on social aspects, which are not explained only by the initial cognitive differences between the dyad peers. These studies examined dyads consisting of a conservative subject and a non-conservative subject (in a Piaget sense). The main contribution of these studies was to bring to light patterns of interaction and of decision-making to solve problems, where the non-conservative subject persuades the conservative subject of the definite solution to the problem, or where the first subject persists in its point of view and directly rejects the second subject's proposed point of view. In other words, in these cases, internal cognitive heterogeneity of the dyad is not necessarily associated with a socio-cognitive modality of interaction on the side of the subject with higher development of the function, but with other issues which are not strictly cognitive (e.g. leadership traits).

In this sense, the aim of this study was to thoroughly analyze socio-cognitive interaction, specifically symmetry/asymmetry between arguments (interaction) of the peers in the dyad in the collaborative resolution of logical items. In other words, the interaction in the dyads was analyzed in two conditions: symmetry between low competence subjects and asymmetry between a high competence subject and a low competence subject. In turn, collaborative verbal interaction considers not only the cognitive aspect, but also the non-cognitive aspects of the interaction.

This article is linked directly to a previous research study (Castellaro & Roselli, 2017), which was focused on the amount and distribution of argumentation in the interaction and its relation with increased individual cognitive performance in dyads with symmetrical and asymmetrical epistemic competences. This research study found very few differences between the symmetrical condition of low competence and the asymmetrical condition (high competence with low competence). This article resumes this comparison and proposes a deep consideration of the data, from a microanalysis of the interaction, which was not considered in the said previous study. It is focused basically on the interaction process itself, being it considered in

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terms of the balance or imbalance of the communication interaction between the peers in the dyad at cognitive and non-cognitive levels. In light of the above, the originality of this study lies in the discriminant category system of the collaborative construction process, which refers not only to cognitive aspects, but also to psychosocial aspects, offering a more ecological view of the interaction.

Method

Design

As said, the purpose of the study was specifically descriptive. It was not intended to verify explanatory hypotheses experimentally. Accordingly, the design had two phases. The first phase aimed to obtain information on the level of initial cognitive competence of the subjects (by a set of logical problems, which will be hereinafter referred to) to form the symmetrical and asymmetrical dyads, which comparison was the heart of the study. The second phase analyzed, using an equivalent set of logical problems, the collaborative interaction process of the selected dyads in order to compare the interactive modality of both types of dyads.

Participants

This study included the participation of 38 fifth and sixth primary school students (19 dyads) (age in years old, M=11.27; SD=0.62) of two public schools in Rosario (Argentine). Out of 19 dyads, there were nine with competence symmetry between the subjects (both with low competence) and the remaining ten with competence asymmetry (one low competence subject and one high competence subject). The sample was formed intentionally. And it did not include atypical cases (e.g. with developmental disorders).

Materials and Procedure

The task consisted of a set of ten increasingly difficult logical items, extracted and/or adapted from the Progressive Matrices Test – General Scale (Raven, 1991). Each item consisted of figures, which were arranged in rows and columns and had a relation of logical sense between each other. The last figure completing the sequence was missing. Each problem resolution entailed deducing the relation of logical sense and proposing the figure completing the sequence, available among eight answer choices. This type of tasks has been used and adapted in various occasions to study the socio-cognitive interaction of children evolutionarily close to formal operational thinking (Rojas-Drummond, Mazón, Fernández & Weferif, 2006; Roselli, 2010, 2011; Wegerif et al, 2016; Webb & Treagust, 2006; Yang, 2016, to mention some recent examples). In other words, the used logical problems did not aim to measure individual intelligence psychometrically, but they were activation devices of the core subject matter of the analysis: dynamics of socio-cognitive interaction.

Initially, each subject solved the set of logical items, preceded by two items of low difficulty, which were used to practice and understand the activity. This initial evaluation yielded a total score between 0 and 10 (recounting of right answers), which was used as an indicator of the initial overall competence level. In consideration of the median value of distribution of total values observed, two overall competence levels were determined: low (0-5) and high (6-10). The dyads with epistemic symmetry (N=9) consisted of two low competence subjects, with a relative difference of ≤2 between their individual scores. The dyads with epistemic asymmetry (N=10) consisted of one low competence subject and one high competence subject, with a relative difference of ≥4 between their individual scores.

During the subsequent two or three weeks, the dyads already formed solved an equivalent version of the logical set of ten items. This parallelism referred to the logical structure of the items, as well as their problem-solving

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behavior, determined by a previous pilot trial in another group of students with characteristics similar to those of the participants in this study. The rationale for the use of a similar version of the task in this collaborative phase was to avoid the parasite effect of retesting, putting the subjects in an ecologically new situation, without presenting reiterative situations. The collaborative instruction given to the peers in the dyads was to work together, discuss possible solutions for each problem and propose a final collective answer (even if they continued to disagree each other). The interaction was recorded in audio, and it was also transcribed.

The project had corresponding evaluation and ethical authorization. Informed consents of each school's authorities, the students' parents and the students (subjects) were obtained. Those without parental permission and/or who did not want to participate voluntarily did not participate in the experiment.

Verbal Interaction Analysis Categories

The analysis unit was each message, consisted of each verbal intervention of the subjects, finished when interrupted or followed by another verbal intervention of the peer. And when it constituted a communication sense unit; therefore, there might be many consecutive messages from the same subject. A system of categories of three levels of inclusion (1, 2 and 3), ordered from high to low levels of generality or inclusion, was used to codify the messages. Within each level, the categories were mutually selective and exhaustive. Construction of this category system was based on previous studies (Chiu, 2000; Kumpulainen & Mutanen, 1999; Roselli, 2004, 2011; Roselli, Bruno & Evangelista, 2004a, 2004b; Roselli, Dominino & Peralta, 2010).

Table 1.

Message Categories and Levels.

Level 1	Level 2	Level 3
Cognitive message	Cognitive affirmation	Cognitive argumentative affirmation (AA)
		Cognitive non-argumentative affirmation (ANA)
		Cognitive procedural affirmation (AP)
	Cognitive question	Cognitive opinion question (PO)
		Cognitive confirmation question (PC)
		Cognitive questioning question (PCU)
		Cognitive demonstration question (PD)
	Cognitive answer	Cognitive argumentative answer (RA)
		Cognitive non-argumentative answer (RNA)
Non-cognitive message	Non-cognitive affirmation	
	Non-cognitive question	
	Non-cognitive answer	

Level 1:

- *Cognitive message*: Intervention of knowledge argument (right or wrong) aimed to solve a problem, which may have been new or repeated during the interaction.

- *Non-cognitive message:* intervention linked to organization or external aspects of the task, not linked directly to the resolution of the task.

Level 2:

- *Affirmations*

- *Questions*

- *Answers* (only it was considered to be an answer the message immediately after a question which had a relation of sense with it).

Level 3:

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- *Cognitive argumentative affirmation [AA]:* intervention by which it is sought to justify or support (in a right or wrong way) an idea related to the solution of the task (Toulmin, 2003), and it does not constitute a question or an answer to an immediately previous question.

- *Cognitive non-argumentative affirmation [ANA]*: intervention by which it is presented an idea related to the solution of the task in a direct manner i.e. without an attempt to justify or support (in a right or wrong way). It does not constitute a question or an answer to an immediately previous question.

- *Cognitive procedural affirmation [AP]:* intervention by which it is proposed a certain action that may contribute to developing an idea to solve the task and/or showing such idea to its peer to solve the task. For example: "*It would be like this. Look"* (and then the subject develops an idea).

- *Cognitive opinion question [PO]*: intervention addressed to a peer to ask for an idea to solve the problem. For example: *"Which other* (answer choice) *might be?"* (a subject asking its peer).

- *Cognitive confirmation question [PC]:* intervention addressed to a peer to query if he/she agrees or disagrees with the asking subject's own idea. For example: *"What do you think to put number 2* (answer choice)?"

- *Cognitive questioning question [PCU]*: intervention addressed to a peer to evaluate and/or review a problem solution proposed by it. In response to the affirmation "Here, I think it's number 5 (answer choice)", the subject answers: *"¿number 5?"* (after that, the first subject says "Yes").

- *Cognitive demonstration question [PD]:* intervention addressed to a peer to show or present an idea or a problem solution. For example, *"Do you see here that it is being formed like this? See?"* (while presenting an idea to the peer).

- *Cognitive argumentative answer [RA]:* intervention that constitutes an answer to an immediately previous question by which it is sought to justify

or support (in a right or wrong manner) an idea related to the solution of the task (Toulmin, 2003).

- *Cognitive non-argumentative answer [RNA]*: intervention that constitutes an answer to an immediately previous question by which it is presented an idea directly related to the solution of the task in a direct manner i.e. without an attempt to justify or support (in a right or wrong manner).

Data Processing

The analysis of socio-cognitive interaction was concentrated on specific problems of the logical set, which reproduced the overall initial symmetry or asymmetry of the dyad. That is, following the criterion used in Castellaro & Roselli (2017), two items which were answered incorrectly in the pretest by both peers were analyzed in the symmetrical dyads; two items where the subject with low overall competence had answered them incorrectly in the pretest and the subject with high overall competence had answered them correctly in the same pretest were analyzed in the asymmetrical dyads. In both cases (symmetry and asymmetry), the two items considered in each dyad may be 5, 6 and/or 8. They had a medium level of difficulty and were considered to belong to the zone of proximal development of the dyad.

The data analysis had three phases. In the first phase, a univariate exploratory analysis of grand totals (corresponding to all dyads) of the categories of level 1, 2 and 3 was carried out. In the second phase, the symmetry/asymmetry of the interaction was analyzed in each verbal category within the dyads with asymmetrical epistemic competence and the dyads with symmetrical epistemic competence. Each individual's arguments were recorded interdependently with respect to those of its peer in the dyad. In this sense, instead of registering the amount of individual messages of each subject, it was registered whether such arguments were "higher than", "equal to" or "lower than" those of its peer in the dyad (as nominal variable). Thus, the association between the level of individual competence (low or high)

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and the degree of argument (lower than, equal to or higher than that of the peer) within the conditions of competence symmetry and asymmetry was analyzed.

In the third phase, taking into account that the previous analysis was focused on detecting general tendencies within each condition (epistemic asymmetry and symmetry), a supplementary case-based analysis was proposed, aimed at identifying the most and least representative types of dyads of the general tendencies detected in the previous step. This distinction between types of dyad was determined according to the symmetry or asymmetry demonstrated in the cognitive and non-cognitive interactions. Thus, for example, a dyad may be symmetrical in the cognitive interaction and, at the same time, asymmetrical in the non-cognitive interaction. To determine the symmetrical or asymmetrical nature in the interaction, either cognitive or non-cognitive, the following criterion was taken: if the difference between the arguments of the peers in the dyad was ≤15% of total messages of such category, the interaction was considered to be symmetrical. If such difference was >15% of total messages of such category, the interaction was considered to be asymmetrical. This reference value (15%) was determined according to the distribution of the observed difference values.

Results

Analysis of grand totals for the dyads in each verbal category (of level 1, 2 and 3).

In general, the dyads registered a total of 564 messages (M=29,68; SD=22,94). Table 2 shows totals corresponding to each message category (distinguishing the category levels 1, 2 and 3).

Table 2.

Grand total of the different types of message (level 1, 2 and 3).

Total messages (n=564)									
Cognitive messages (n=432)									Non-cognitive messages (n=132)
Cognitive affirmations 326			Cognitive questions 65				Cognitive answers 41		Non-cognitive affirmations 120	Non-cognitive questions 4	Non-cognitive answers 8
AA	ANA	AP	PO	PC	PCU	PD	RA	RNA			
127	189	10	14	23	14	14	10	31			

AA: Cognitive argumentative affirmation / ANA: Cognitive non-argumentative affirmation / AP: Cognitive procedural affirmation / PO: Cognitive opinion question / PC: Cognitive confirmation question / PCU: Cognitive questioning question / PD: Cognitive demonstration question / RA: Cognitive argumentative answer / RNA: Cognitive non-argumentative answer

Out of total messages, 76.6% were cognitive (the other ones were non-cognitive), indicating that most of verbal arguments of the dyads were aimed at task-resolution. Also, it is worth mentioning that there were no or few messages completely unrelated to the task, which explains why a category in this respect has not been proposed. Moreover, it was observed strong predominance of affirmations (79.1%) as compared to questions (12.2%) and answers (8.7%). In other words, the subjects preferred to directly give proposals, instead of exchanging questions and answers with their peer. Simultaneously, most questions and answers present in the interaction were cognitive, which confirms the said clear predominance of verbalizations aimed at task resolution.

The amount of argumentation (137 messages), an important element to indicate the quality of the interaction, accounted for 24.3% of total

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messages and 38.9% of cognitive affirmations. In spite of this, 92.7% (127) of argumentative messages were affirmations and the rest were answers to previous questions. This ratifies the previous result holding that, even though the dyads have showed a significant proportion of cognitive messages (directly linked to task resolution) and argumentation, they predominated in the form of affirmations, rather than the interaction between questions and answers.

Analysis of the symmetry/asymmetry of the interaction between the subjects in the dyads, in symmetry and asymmetry of epistemic competence.

The results pointed out that the initial competence asymmetry is associated with an asymmetry in the provision of general messages (x^2=7.20, p<.01) for the most competent subject (in 8 out of 10 cases). With regard to categories of level 1 (cognitive and non-cognitive messages), predominance of cognitive messages was also observed for the most competent subject (in 6 out of 10 cases), although it did not reach statistical significativity (x^2=4.00, p>.05), whereas the distribution of non-cognitive messages was much closer between the peers. With respect to categories of level 2, it was observed a significant inequality for the most competent subject, only with respect to cognitive affirmations (x^2=7.14, p<.05). In the case of cognitive questions and cognitive answers, although it did not reach statistical significativity, it is worth noting the descriptive values for the epistemic asymmetry condition: whereas cognitive questions predominated in the least competent subject (in 5 out of 10 cases), cognitive answers predominated in the most competent subject (in the same proportion, too). For their part, with regard to epistemic competence symmetry, all the analyzed categories (overall amount, categories of level 1 and 2) showed much more equal and distributed interactions, which explains the absence of significant statistical differences.

With respect to categories of level 3, in the dyads with asymmetry of epistemic competence, significant differences were observed in cognitive argumentative affirmations (x^2=10.89, p<.01) for the most competent subject,

too (in 8 out of 10 cases). However, more equal arguments were noticed in the rest of the codes (without significant differences between the peers in the dyad), except for the cognitive non-argumentative answer code, with strong presence in the least competent individual, although without a significant difference with respect to its peer with high competence (x^2=2.57, p>.05). For their part, the same categories of level 3, with regard to symmetry of epistemic competence, did not show significant differences between the peers in the dyads.

Case-based analysis of dyads within each condition (competence symmetry or asymmetry).

Types of dyads with initial asymmetrical epistemic competence.

As mentioned above, this analysis was aimed at identifying specific types of dyad taking as a differentiating criterion the equilibrium and disequilibrium between the cognitive and non-cognitive arguments of their peers during interaction. Thus, the most and least representative cases of each condition were detected (asymmetry and symmetry of epistemic competence) according to the general tendencies observed in the previous block of results.

In the condition of asymmetry of epistemic competence, it was observed four types of dyads, beyond the multiple possible types that may be formed *a priori* according to the combination between the argument symmetry/asymmetry, its nature (cognitive/non-cognitive) and the level of competence of the subject with lower/higher argument (low/high).

A *first* dyadic *type* was marked by total asymmetry (at cognitive and non-cognitive levels) for the most competent subject (cases K. and S, L. and

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A., C. y A.). There is total asymmetry in the interaction because leadership refers not only to task resolution, but also organization and social regulation of the activity. This is illustrated in fragment 1.

Fragment 1. L. (low competence) and A. (high competence) in item 6

L.	*Number 7.*
A.	*Number 1* (silence).
A.	(L. writes down "7", but A. corrects) *No, number 1.*
A.	*Because here there are two, here this one is added and here the last one is added …* (figures C, F, answer choice 1).
A.	*And here it cannot be this because these two are missing …* (A. eliminates one choice)…
A.	*… This because it is on this side* (A. dismisses another choice).
	…this one because one is always added … (L.
A.	dismisses another choice).
	…and here because they are separated and
A.	*here because it's the same …*
	…oh sure, because… (inaudible)
L.	*Let's see, wait … or it may be number 5 …*
A.	(silence)… *or number 4…*
	Number 4…
L.	*No, but look. In A they are like this* (layout)…
A.	*Aaahhh*
	…here it is added 1, in D, and in G other is
L.	*added and remains like this.*
A.	*The 3 are in B, the 4 are in E, it is added …*
	Yes, here, to the other …
L.	*And the 2 are in C, it is added 1 in F and in*
A.	*the remaining one it may be added this on the bottom or this on the top …* (L. refers to internal circles in each figure)
	That's why … yes, yes, I now understand …
L.	(they think)
A.	*I think it's …* (both make a prolonged silence)…
A.	*Then, it may be any …* (with 4 internal circles)
A.	*That's why …*
A.	*I think it is this, number 5.*
L.	*It's already here …* (A. refers to figure E).
	(A. corrects) *No, this… because it's not repeated …*
A.	*Sure, that's why …*
L.	*¿Number 1?*
A.	*Yes.*

Fragment 2. B. (low competence) and J. (high competence) in items 5 and 6.

J.	*This is good …* (J. refers to the problem) (silence).
B.	*This is complicated …* (silence).
B.	*Should it be a complete one?* (B. refers to a possible answer).
J.	*We should see how the others are drawn.*
B.	*Because some are complete, and other are completely painted, but they're half drawn…*
	You see?
B.	*Yes.*
J.	*B is half painted* (both make silence. They
B.	think)
	Number 5?
B.	*No, I got it* (present among the answer
J.	choices) (silence).
	I believe… I think it's number 2 because
J.	*another doesn't seem right to me …*
	Yes, it may be. Because there is one that it's
B.	*fully incomplete* (C)*, one that it's for the half* (F) *and the other is full* (number 2 chosen).
	Yes, number 2.
	Do we choose number 2?
B.	*Yes.*
J.	*This is like this, look… 4,5,6* (J. counts
B.	internal circles in the figures).
J.	*Look. You should see the way they are filled. 4* (dots) *with one in the middle let's say* (A)*,*
J.	*5 like this* (D) *and 6 like this* (G)*.*
	Do you see that here it is being formed like this?
J.	*You see?*
	And here it goes like this … (silence).
J.	*It should be … sure, number 1.*
J.	*Yes, it might be.*
B.	*And yes, because, look, see?*
J.	*It is being completed like this* (J. points out)
J.	*to become this one.*
J.	*Like this* (C)*, like this* (F) *and this is missing* (choice 1)
B.	*Yes, number 1.*

At the same beginning of the interaction, it is noticed that L. directly proposes a (wrong) solution, and A. presents another (right) answer choice. In absence of feedback by L., A. starts to present arguments to support its proposal, and uses its argument to dismiss other possible answer choices. At a certain moment, A. doubts of its answer and proposes an alternative. L. also adheres this new idea, which would be suggesting that it had not understand A.'s previous explanation. After that temporary doubt, A. ratifies the initial idea and reiterates the rationale of its decision (it arguments). It is unclear if L. understands its peer's explanation, though the final question (of confirmation) might be suggesting that. After that, L. restricts itself to agreeing with A.'s idea, but it does not enrich or problematize cognitively the meaning compromised by it, which, by the way, is consistent with the correct solution of the problem.

A *second type* of dyad, observed in a case (C. and A.) only, was similar to the previous one, but with the particularity that an absolute asymmetry, cognitive and non-cognitive, of the subject with high competence did not occur, but such disequilibrium of the argument refers to the cognitive only. This type of dyad is also different from the previous one due to low amount of verbalizations. In this case, the subject with high competence (A.) only proposes a solution answer without a previous agreement or dialogue with its peer (C.), who only accepts it in a passive and discrete manner (one or two messages only). Thus, what it might be understood as an "equilibrium" in the non-cognitive interaction, in fact it is the product of little interaction, only focused on proposing an answer choice. Moreover, poor cognitive interaction is associated with a final wrong answer in the collaborative item.

The rest of the dyads of the condition of asymmetry of epistemic competence showed a more exceptional nature according to the observed tendencies in the block of results of item 2. Thus, a *third* identified *type* of dyad (B. and J., F. and L., M. and L., J. and M.) is marked by symmetrical interaction, both cognitive and non-cognitive, despite the disequilibrium between the subjects' initial competences. This can be observed when

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the interaction adopts a tutorial modality, in which there is a permanent interaction between both peers, although cognitive leadership is driven naturally by the subject with high competence. Fragment 2 of B. and J. (see above) illustrates the above, where it is observed that, although there is an equitable and natural interaction between both peers (of cognitive and non-cognitive arguments), the most relevant keys for problem-solving (linked to the categories of level 3) come from the most competent subject (B.). In both reported items, the proposed final answer was right.

Furthermore, this equilibrium in the cognitive and non-cognitive interaction registered in this type of dyad can occur in a more imposing or unilateral manner than in the previous case of B. and J., which had showed a more tutorial nature. In this sense, as observed in fragment 3 (F. and L.), it can occur that the most competent subject (in this case, L.) provides different cognitive keys throughout the interaction, while the least competent subject

(in this case, F.) seeks to feed such reasoning line giving other cognitive comments, though less relevant in terms of the core of problem-solving.

Fragment 3. F. (low competence) and L. (high competence) in item 5

	(silence)
F.	*I thought it was extremely difficult …* (equivalent version in individual evaluation) (silence)
	Ah, I know … (like thinking to herself)
L.	*I don't understand …*
F.	*Wait, wait….* (L. continues looking)
L.	*It will be this one …*
F.	*Which?*
L.	*Number 3* (answer choice) (silence).
F.	*Because it isn't number 6* (answer choice) …
F.	*Let's see, wait…*
L.	*It isn't number 1* (answer choice)*, because it's*
L.	*here, it's in H.*
	Number 2… (answer choice) (silence) … *may*
L.	*be …*
	That's why … number 3 (answer choice) *isn't*
F.	*here …*
	Not… (silence)
L.	*Number 2* (answer choice). *I think it's number 2.*
L.	*Number 2 is here.*
F.	*It isn't. It is here, but with vertical lines* (figure
L.	A).
F.	*Aaahh.*
L.	*Look, I think it's number 2 for this reason: here, everything is straight in C, then it start with the little lines* (inaudible) *and then all the little lines remains* (although the middle part is inaudible, it's clear that L. makes the sequence of Row 1 or Column 3; C,B,A or C,F, choice 2).
L.	*This one is square* (figure G), *half and half* (figure H) *and all little lines remains* (choice 2).
F.	*Yes…* (like thinking)
L.	*I don't know what you think … I think it's like this.*
F.	*And yes …*
L.	*I think it's number 2.*
F.	*Yes, number 2.*

Fragment 4. L. (low competence) and C. (high competence) in items 5 and 8

	(silence)
L.	*Number 8?* (answer choice)
C.	*Yes, number 8* (answer choice)
L.	*Don't give your opinion on what I'm saying because…*
C.	*No, no…*
L.	*Number 8?*
C.	*Yes*
L.	*Number 8 or 2?*
L.	*Look… because, do you see they are like this?*
C.	*Ah, it's true … number 2.*
L.	*Number 2?*
C.	*Number 2.*
L.	*Ok.*
	(silence)
L.	*Number 2?* (answer choice)
C.	*Number 2…* (like thinking)
L.	*Number 3, 4, 5…* (silence)
L.	*Which?*
C.	*I don't know …* (silence)
L.	*I think it's number 2. Number 2 isn't here.*
C.	*It's true.*
L.	*Number 2?*
C.	*Number 2.*

Finally, the *fourth* identified *type* of dyad resulted to be the most atypical one because it was marked by a disequilibrium of the cognitive argument for the subject with low competence, in combination with an equitable non-cognitive interaction (dyads of J. and F., L. and C.). In spite of this, a more

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exhaustive analysis (for example, from fragment 4 of L. and C.) makes it possible to clarify what this "cognitive superiority" of the subject with low initial competence is (in this case, L). The fragment shows that, although L. proposes a greater amount of cognitive interventions, most of them are questions addressed to C. (with high competence) in the form of enquiry or request of assistance. In other words, it is a pattern where the subject with low level of competence, even though with a very active verbal role, depends on the most competent peer, who does not feed such questions with tutorial cognitive interventions (as it happened in the previous dyad of B. and J., fragment 2) and only gives one or two minimum keys to solve the problem. In addition, the overall amount of messages of the dyad is low.

Types of dyad with initial symmetrical epistemic competence

A case-based analysis similar to the previous one (based on simultaneous consideration of cognitive and non-cognitive symmetry/asymmetry) was carried out in the dyads with epistemic competence symmetry. They showed greater internal homogeneity than the dyads with competence asymmetry. Two basic types can be distinguished.

A *first type* of dyad, the most representative one of the general tendency registered in item 2 and present in six cases, was defined by a balance in the cognitive and non-cognitive interaction (J. and V., L. and M, L. and G., P. and L., A. and B, J. and F). In fragment 5 (J. and V.), it can be observed the significant and equitable interaction between both peers, which is manifested not only through affirmations, but also through question-answer micro-cycles. In spite of this, the cognitive aspect of the interaction is not of high quality due to lack of argumentations and adoption of a resolution strategy based on dismissing answer choices from poorly grounded criteria, resulting in a wrong problem solution.

Moreover, it is noted a *second type* of dyad (cases C. and L., B. and J., A. and M.), marked by a disequilibrium of the cognitive arguments, but

with symmetry in the non-cognitive interaction. This can be considered to be more atypical than the previous case as a direct relation between equality of competence and equality of the cognitive argument is mostly expected. In this sense, it is interesting to review the interaction of C. and L. (fragment 6) to try to better understand this phenomenon. Firsthand, the fragment shows an equitable and distributed general interaction (for example, there are affirmations and questions-answers, too). In spite of this general picture, C. plays a little more active than its peer, which is manifested by an increased frequency of cognitive messages, even the only argumentations present in the interaction come from it. Moreover, it should be noted some signs of L.'s tutorial intention, which is manifested by demonstration questions (for example, "…is by number, *you see?*" or "Because you should continue to add, *right?*"). This fragment results interesting because, in spite of L.'s actions, the dyad fails to successfully solve the problem, which may be explained by both peers' low level of initial competence. Even, L.'s active behavior may

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be explained by other involved non-cognitive aspects, as it may be the case of ancestry, leadership or sociability traits.

Fragment 5. J. and V. (both low competence subjects) in item 6.

V. *Let's see* ... (the subject counts the dots of each figure)… *four, three*... (figures A,
J. B…).
(J. counts with V.) *And if it's ... number 5 isn't ...* (answer choice 5) (silence).
J. *Or, it may be number 5!*
V. *I think it's number 5* (silence)
J. *Wait a minute…*
V. (silence) *I don't know ...* (silence)
J. *Which is the one that never appears?*
V. *This one* (the subject points out the figure).
J. *That's why ... it doesn't fit, but it cannot be ...*
V. *Yes, but, look. Figures E and A have the same dots, but in a different order. Four and four.*
V. *And number 3...* (inaudible 3.33)
J. (silence)
(they seem lost) *Look. I don't know ...*
V. *I don't understand this ...* (silence)
V. *Let's put…*
J. *Let's put number 3?*
V. *I don't know ...* (silence).
V. *Let's see, wait…* (silence).
V. *I believe it would be number 4.*
J. *Are you sure number 4?*
V. *Yes.*
J. *I don't think so ...* (silence)
J. *Let's see ... well, number 4.*
V. (but after that, V seems to change its mind) *Let's see, let's see ... wait, wait…don't put it yet ….*
V. *I don't know if it's ... is like the pyramid ...*
J. *Well, tell the answer.*
V. *The answer to exercise 6 is number 6*
J. *Number 6?*
V. *Yes, because it would be like the pyramid.*
J. *Yes* (apparent little certainty)

Fragment 6. C. and L. (both low competence subjects) in item 6.

C. *Well, it is this one ...* (silence)… *In A, how many little balls are there? Four.*
L. *Yes.*
C. *Eh, wait... sure, it's by number, you see? 4,5 and 6* (internal circles of each figure).
C. *In A there are 4, in D there are 5 and in G there are 6.*
C. *And, in B there are 3, in E there are 4 and in H there are 5.*
C. *And, in C there are 2, in F there are 3, there here* (final answer) *there has to be 4.*
L. *Number 2?*
L. *Or number 3…*
C. *Or number 5.*
L. *Or number 5, many have 4* (circles*)*
C. *Number 2, number 3...* (C. reviews possible answer choices)
L. *I think it's ...*
C. *I think it's number 4* (selected choice).
L. *Why?*
C. *Because you have to continue adding*
C. *Ok…?*
C. *In these two this one was added* (C1)
C. *And in these two this one is added* (C2)
C. *Then what do we put? Number 5*
L. *Number 5?*
C. *Yes, because there are three.*
L. *Ah, yes.*
C. *Yes, number 5.*

Discussion

Cognitive interaction is a process by which two or more individuals are united to carry out an activity together, which generally involves construction of knowledge/concepts or logical problem-solving, as it occurred in this study.

It can be stated that socio-cognitive interaction (and the various forms it can adopt) is the product of the conjugation between two planes: on one hand, the individual cognitive competence of each participant, and on the other hand, the personality and relational variables (psychosocial) which intervene in the quotidian interactions. In this sense, collaborative problem-solving -read, in an *intersubjectivity* context (Rogoff, 1990) raises the challenge of resolving the task (providing cognitive *clues or keys*) and resolving the relation with the *alter* (through different possible forms of *intersubjective coordination)*.

To illustrate the above, it can be alluded to what could occur in the hypothetical situation of a dyad consisting of subjects with levels of very dissimilar cognitive competence, i.e. with high cognitive asymmetry with respect to the task. In that situation, it is likely that the individual with high competence comparatively generates a high degree of cognitive arguments with respect to task resolution. However, it can be manifested through different forms of linkage with the least competent *alter*, generating diverse interactive dynamics. One of these may be unilateral imposition, without considering or waiting the peer's opinion. Whereas, another form of linkage may adopt tutorial traits, providing the cleverest peer diverse cognitive keys to resolve the task, not imposing them, but trying to accompany and support its peer so it can understand them. Likewise, the subject with low competence may adopt diverse reactions, for example, it may either retract and adopt a passive role, or feed the interaction and participate actively in the arguments proposed by its peer.

The above links to a central issue which has been gone through by the study and constitutes the heart of this discussion. Even though it was mainly aimed at analyzing the socio-cognitive interaction process in dyads formed with a cognitive symmetry and/or asymmetry criterion, it was proposed a perspective which takes into account and differentiates the cognitive and non-cognitive aspects of the interaction. To accomplish it, two supplementary analytical criteria were proposed: a) construction of a category system composed of three levels of inclusion to detect general tendencies in the

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sample; b) case-based analysis aimed at detecting specific types or particular groups of dyads according to the manifested interactive behavior.

Firstly, the analysis of the detected general tendencies (by the way, the most regular perspective in the literature evidenced that most weight of the dyadic interactions (both symmetrical and asymmetrical) fell on the cognitive dimension. This means that the subjects were concentrated principally on interacting to find a solution to the problems. However, when the analysis started to differentiate the symmetry and asymmetry conditions, some significant differences were noticed, consistent with previous literature (Denessen, Veenman, Dobbelsteen & Van Schilt, 2008; Schmitz & Winskel, 2008; Tudge, 1992). The biggest differences in the asymmetrical dyads occur both in the general amount of messages and in the amount of cognitive messages, especially the argumentative ones, always for the subject with high competence. In contrast, in the symmetrical dyads, an equilibrium in the distribution of interventions in most categories is observed. In this sense, this finding confirms the general conclusions of previous research studies, which recognize that the level of initial competence plays an important role in the interactive interaction level, specifically in the cognitive dimension.

However, secondly, case-based analysis of particular and unique aspects of the different dyads allowed a further deepening of the analysis, making it possible greater discrimination within the general tendencies mentioned. In this sense, it is worth recalling that researching cognitive processes should be aimed at extracting not only general conclusions, but also differential conclusions (Castellaro & Roselli, 2012). Thus, specific observable types in both symmetrical and asymmetrical dyads could be distinguished and identified.

With respect to asymmetrical dyads, it is clear that cases fitting into the general tendencies mentioned, i.e. cognitive asymmetry for the most competent subject, with asymmetry or symmetry at non-cognitive level, were identified. However, interactive modalities marked by more exceptional dynamics were also found, which is interesting as they reveal

subtler differences. For example, some dyads with competence asymmetry between their components showed symmetrical interactions at both cognitive and non-cognitive levels, which allows to conclude that inequality of initial competence is not always translated into an unbalance between the subjects' arguments. This was the case of the dyad of B. and J., where the subject with less competence played an active role and had a permanent cognitive interaction with the peer with high competence, regardless its intents so that its less competent *alter* understands the problem. In this sense, the active and constructive role of the least competent subject constitutes a condition as important as the interactive style proposed by its most competent *alter* (Gabriele, 2007).

With regard to competence asymmetry, other divergent examples were those cases with greater cognitive arguments by the least competent subject. In fact, despite such lower cognitive competence, it shows high participation (similar to the previous case of B. and J.), consisting basically of questions and cognitive requests to the most competent subject, who demonstrates poor reciprocity and tends to act by its own. This non-participating attitude might be explained by a non-cognitive trait (for example, a personality or social attitude trait) as, beyond having the cognitive resources to solve the problem, it prefers to generate minimum arguments during the interaction. Although they do not constitute totally equivalent situations, the said interactive dynamics adds evidence for those studies which have reported cognitive interactions contrary to the expected according to the differences of cognitive competence of the subjects (for example, Psaltis & Duveen, 2006, 2007; Zapiti & Psaltis, 2012). In other words, in those cases the internal cognitive heterogeneity of the dyad is not necessarily associated with a socio-cognitive interaction modality for the most competent subject, but with other non-cognitive matters (for example, leadership traits).

For their part, in the symmetrical dyads, there were cases not only with equitable cognitive and non-cognitive interactions (according to the expected), but also with cognitive unbalances for one of the peers. In this

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case, in spite of their cognitive insufficiency, one of the subjects leads the other in the cognitive argument, either proposing keys (although they are wrong) to resolve the task or seeking to generate basic coordination with the peer. Here, it is also necessary to resort consideration of supplementary non-cognitive variables that may influence the interaction.

As final conclusion, it can be said that symmetrical and/or asymmetrical balance which may be detected within each dyad does not necessarily suggest that greater cognitive competence directly results in a greater role in task resolution, in other words, this does not depend only on the degree of comparative competence. It is like this because an interactive social process, though it deals with logical issues or tasks, is marked by psychosocial and/or personality factors, which articulate with levels of cognitive competence, generating a complex framework in which sometimes cognitive supremacy predominates and in other occasions it is counterbalanced by these external non-cognitive factors. This conclusion opens the way for a methodological approach with a clearly ecological sense, in which the subjects are not considered merely in their cognitive sufficiency aspect, but as social actors in interaction (Psaltis et al, 2009; Quianzade et al., 2014). This evidences the need for designing studies that consider and take into account not only intellectual competence variables, but leadership aspects, personal ancestry, rivalry and social comparability.

The difficulties found in the study, fortunately successfully overcome, were mainly access to field and fieldwork. Firstly, some participants, initially available, were dismissed because the study did not have their corresponding consent. Secondly, data collection took a considerable amount of time due to the need of audiorecording the interactive sessions, an indispensable element to analyze the collaborative construction process. Finally, it should be noted that the data collection was carried out in schools, which generally raises the

challenge of adjusting the research process to emerging requirements and difficulties.

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