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Running head: Social Cognition Trajectories

Developmental trajectories of social cognition from preschool to adolescence

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Abstract

This longitudinal study aims to define the developmental trajectories of social cognition (SC) in a community sample ($N = 378$) assessed from preschool (3 years old) to preadolescence (12 years old). Parents and teachers reported on a SC measure at ages 5, 10, and 12. We tested the existence of different trajectories and whether they discriminated outcomes in early adolescence. The data were collected from different sources, the children, the parents, and teachers, by means of different methods. Using Growth Mixture Modeling (GMM), we identified three distinct social cognition trajectories: persistently mild difficulties reported by parents and teachers (7.9% of the children), stable low problems reported by parents and increased difficulties reported by teachers (10.5% of the sample), and stable low problems reported by both informants for most of the participants (81.5%). Comparison of the psychological outcomes between classes using regression models showed that the two trajectories including children with any level of problems differ from the normative one as regards their association with psychological problems, daily functioning, and variables such as aggressive behavior and callousness. The two non-normative trajectories also differ from each other in terms of the personal characteristics of the adolescents included in them. Adolescents in the increasing problematic class in the school have a tougher and more problematic style of social relating, while children with persistent and non-context-dependent difficulties are more anxious. These results might help to better detect and design specific interventions for children with deficits in SC that might respond to different personal characteristics leading to different outcomes.

Keywords: Growth Mixture Modeling, multi-informant, SCDC, Social cognition, trajectories.

Developmental trajectories of social cognition from preschool to adolescence

Social cognition (SC) has been conceptualized as the faculty to perceive emotions, intentions, and behaviors in oneself and others. It is indispensable to properly adapt to other's demands (1). Deficits in these domains are transdiagnostic and defining features of neurodevelopmental disorders such as ADHD, autism, and schizophrenia, in addition to conduct problems (2) (3), social anxiety, and depression (4). The large number of associations between SC difficulties and many other mental health problems highlights the relevance of attempting to understand and prevent them.

Normative development of SC has been well established (5)(6)(4), pointing to preschool age and adolescence as critical periods for “social brain” development. While basic social cognition skills develop throughout childhood (e.g., recognizing straightforward emotions, theory of mind), more complex skills and the structure and function of associated brain networks emerge and continue to develop across adolescence and young adulthood, including the ability to recognize complicated emotions (e.g., sexual/romantic interest, fear, contempt) and social perception skills (e.g., detecting white lies, irony, dares).

Advances in brain imaging technology have recently facilitated increased understanding of structural and functional changes and provided evidence for the continued development of the brain areas involved in social activities during adolescence (7). Adolescence is therefore a key period for development, as fact that could be related to the number of changes that take place in this period, including hormonal and socio cognitive maturation (8). Given that the acquisition of complex social information is at its highest in this developmental stage (9), it is an opportune time for intervention to alter patterns of attributional biases or other related difficulties. Nonetheless, precise timings and trajectories of structural developments in brain areas

within these networks show substantial variation between individuals (10). It has been proposed that individual differences in the developmental trajectories of neural circuits and the cognitive processes they subserve interact with environmental factors, manifesting in a unique neurocognitive developmental profile (11). Increasing our understanding of the development of these abilities and the way in which they relate to certain outcomes may also provide insights into why some adolescents are successful in making the transition to adult life, while others experience difficulties.

The study of developmental trajectories by means of identifying different groups of children according to their level of difficulties and their growth or decline over time enables us to better understand the evolution of deficits and disorders. It may also allow us to identify the developmental ‘windows’ when individuals may be particularly vulnerable, knowledge that is vital to understand who is at greatest risk and how to design effective early interventions (12).

Data for SC developmental trajectories are scarce. (13) studied the evolution of a specific aspect of social cognition, facial emotion recognition, and the role of age, gender, and puberty in this ability. (8) examined the developmental trajectories of social anxiety in a non-clinical sample and the role of temperament, social competence, and cognition in discriminating between trajectories. To our knowledge this is the first study on trajectories of social cognition using data that represents a wide range of daily social interactive behaviors underlying the complex construct of SC and that combines information from parents and teachers, as would be done in real clinical assessments. Older children and adolescents are characterized by increasing autonomy and parents are no longer the only adults sharing their social life or observing their social interactions. Teachers are also principal actors and essential informants (14) (15).

The aims of this study are 1) to contribute with data based on different informants' observations of a sample of Spanish adolescents for the purpose of tracing the developmental trajectories of SC from ages 3 to 12, and 2) to ascertain the discriminative ability of these trajectories for different outcomes at age 12 in order to identify potential groups of adolescents with different levels of difficulties and the potential variables related to better detect and treat them.

Method

Participants

The data used in this study correspond to the third, eighth, and tenth waves of a longitudinal research project about vulnerability to behavioral problems in preschool children. The research was conceived with a two-phase design and was based on an initial random sample of 2,283 children selected from all registered preschoolers (age 3) in Barcelona (Spain) during the 2009-10 academic year. Children with an intellectual disability or pervasive developmental disorders were not included in the study.

The proportion of families that agreed to participate in the first phase was 58.7% ($N = 1,341$ families) and no differences were found when comparing participants and refusals according to sex ($p = .95$). However, the proportion of refusals was statistically higher for families from low socio-economic groups ($p < .001$). The screening for the children to be included in the second phase was carried out using the parent version of the Strengths and Difficulties Questionnaire for 3- and 4-year-olds (SDQ³⁻⁴; Goodman, 1997). All the children with a positive screening score for conduct problems, in addition to a random sample including 30% of the children with negative scores in the screening, were invited to continue with the longitudinal research program. The final second-phase sample included 89.4% of the families invited to continue ($N = 622$), and no statistical differences were found regarding sex ($p = .820$ for participants and refusals), although

more families that agreed to participate had a higher socio-economic status (SES), (16), than those that refused ($p = .007$). The mean initial age of the children was 2.97 years ($SD = 0.16$). Of the participants, 310 were boys (49.8%) and 558 were Caucasian (88.9%).

The sample used for this study consisted of 378 children (66.1% screen-positive) (Table 1). Those for whom there were data from 2 or all 3 possible annual follow-ups at ages 5, 10, and 12 represented 60.8% of the initial sample at age 3 [60.1% from the positive screening group and 62.1% from the negative screening group; $\chi^2(1) = 0.24, p = .624$]. No differences were found in sex between the initial sample at age 3 and the children at ages 5, 10, and 12 ($p \geq .234$). With respect to socioeconomic status at age 3, the available sample at age 12 had a higher percentage of high SES children ($p = .033$).

Measures

The *Social Communication Disorders Checklist* (SCDC; (17)). This is a 12-item questionnaire with situations rated according to whether the corresponding behavior has been seen during the previous 6 months and is answered on a 3-point Likert scale (0: *not true*, 1: *quite true*, and 2: *very true*). In this study, it was answered by both parents and teachers. The items enquire about the extent to which a child has difficulties in perceiving others' feelings and moods and recognizing the consequences of their own behavior in the environment, which are central aspects of SC. In this case, the items were completed using the Spanish validation (18). Higher scores indicate greater difficulties. Children with high scores have poor reciprocity skills in social relations and may show poor communication skills. The total SCDC score was used to derive the trajectories. In the present sample, ordinal alpha values were .95 and .89 at age 5, .96 and .92 at age 10, and .95 and .92 at age 12 for teachers and parents, respectively.

The Strengths and Difficulties Questionnaire (SDQ (19)) is a brief mental health screening questionnaire. In both the parent and teacher versions the 25 items have 3 response options (0: *not true*; 1: *somewhat true*; 2: *certainly true*) and are distributed in 5 five scales: emotional problems, conduct problems, hyperactivity-inattention, peer problems, and prosocial behavior. Ordinal alpha in the sample at age 12 for parents and teachers' responses was .92 and .91, respectively.

Child Behavior Checklist (CBCL 1^{1/2}– 5 and CBCL 6-18; (20). The CBCL measures behavioural and emotional problems through 100 items with 3 response options (0: *not true*, 1: *somewhat/sometimes true*, 2: *very true/often true*), and it was answered by the parents. Empirical and DSM derived scale scores were used. Ordinal alpha in the present sample for the empirical scales was .87, .89, and .86, at ages 5, 10, and 12, respectively.

Diagnostic Interview of Children and Adolescents (DICA-P)(21). The DICA is used to assess children's psychopathology according to the DSM-IV/DSM-5 taxonomy (22)(23). It was answered by parents, having been adapted and validated for the Spanish population, showing good psychometric properties. The DICA diagnoses analyzed as outcomes were disruptive behavior disorders (ADHD, ODD, and CD). Use of services was registered after assessment of the symptoms of each disorder. Inter-raters' agreement was previously studied and ranged from kappa coefficients 0.83 to 1 for the different diagnosis, indicating a good to excellent agreement between interviewers (24).

The Children's Global Assessment Scale (CGAS (25)) is a global measure of functional impairment rated by the interviewer based on information from the diagnostic interview. Scale scores range from 1 (maximum impairment) to 100 (normal functioning). Scores above 70 indicate normal adaptation. The CGAS was completed at

age 12. Interclass correlation coefficients valuing interrater agreement of 0.92 were obtained for the parent's version (26).

Inventory of Callous-Unemotional traits (27). It includes 24 items coded on a 4-point Likert-type scale (0: *not at all true* to 3: *definitely true*) and attempts to measure the degree to which the child is unaware of other people's feelings and does not care about behaving in a socially acceptable way, the degree to which the child worries about completing duties and accepts mistakes and their consequences, and the child's difficulties in sharing emotions or openly expressing feelings. The Spanish version and total score were used (28). Internal consistency (Cronbach's alpha) for the total score of the sample at age 12 was .89. In this study, the ICU was answered by teachers.

Children's Aggression Scale (CAS; (29)). The CAS assesses aggressive behavior with 22 items on a 5-point Likert-type scale (0: *never* to 4: *many days*). This questionnaire was answered by teachers when the children were 12 and the total score was used. Cronbach's alpha at the 12-year-old follow-up was .87

Pubertal Development Scale (PDS; (30)). The PDS has been reported to be a reliable measure of pubertal development. It is a sex-differentiated questionnaire with four answer options, each indicating a more advanced stage of physical changes that occur in adolescence, (e.g. breasts or pubertal hair growing, voice changes, etc.). The boys' version has 4 items, and girls are asked an extra dichotomic question about menarche.

Children self-informed at age 12, answering three *yes/no* questions about relationships with friends: *Do you usually have conflicts with friends? Is it difficult for you to make friends? And, Is it difficult for you to keep friends?*

Procedure

The project was approved by the ethics review committee of the authors' institution. The head teachers of the participating schools and the children's parents received a complete description of the study. The families were recruited at the schools and gave written consent. All the parents of the children in P3 (aged 3) in the participating schools were invited to answer the SDQ³⁻⁴ at home and return it to the schools. The families who agreed and met the screening criteria were contacted by telephone and interviewed yearly at the school throughout the entire 8-year period. The interviewers had previously received training and were blind to the children's screening group.

Both parents and teachers answered the SCDC at ages 5, 10, and 12 and the SDQ used for these analyses was completed at age 12. After the structured interview, the interviewers completed the CGAS.

Statistical Analysis

The statistical analysis was carried out using MPlus8.4 and Stata16. Given the multistage sampling procedure used, the analyses were weighted by the inverse probability of selection in the second phase of sampling. Because rating of children provided by teachers was nested within teachers and within schools, the suitability of a multilevel approach was checked by calculating the intraclass correlation coefficient of the intercept only model for the Teacher's total SCDC scores, entering school as a random factor (31).

Growth Mixture Modeling (GMM) with two parallel processes was used to identify distinct groups of individual trajectories for joint SCDC direct ratings from parents and teachers, adjusted by pubertal development direct scores at age 12. This

decision was made based on the processing model of adolescent development (4)(32), which proposes that hormonally induced changes in socio-affective systems result in increased salience of social contexts in adolescence. The Robust Maximum Likelihood (MLR) method of estimation, which enables the inclusion of non-normal and incomplete data, and the expectation maximization algorithm for missing data with robust standard errors (i.e. full information method), were used. The growth models considered intercept (I) and slope (S; i.e. linear trend) over the three annual assessments available, at ages 5, 10, and 12. Time was rescaled to 0-5-7, so the first-year assessment (at age 5) represented the intercept (i.e. the basal direct score).

Models with one to four latent classes of growth patterns were obtained. The following criteria were used to determine the best model and to show the best clinical interpretability: larger decrement in AIC and sample-size adjusted BIC (aBIC), greater power and more accurate classification by average posterior probabilities, entropy values equal to or greater than .70, and more than 20 participants in a class/trajectory.

Once the optimal number of classes had been defined, different demographic and psychological outcome measurements at age 12 were compared between classes using multiple post-hoc comparisons. Linear models for continuous measures, logistic models for binary measures, and multinomial logistic models for polytomous measures were estimated. When the outcome was available at age 3, it was introduced in the models as an adjustment term. Because of the large number of comparison the false discovery rate (FDR) was applied to control the Type I error (33) (34). Hedges' *g* effect size (35) was calculated for each significant class comparison. According to (36), absolute values were interpreted as null effect for values < 0.20 , small effect for values $0.20-0.50$, medium effect for values $0.50-0.80$, and large effect for values > 0.80 .

Results

The level of nesting between children-teachers-schools was low. At 12 years-old 71 schools participated, almost half of them having only 1 or 2 teachers and with a maximum of 7 teachers for one school (the mean was 2.74 participating teachers by school). At the same age a total of 121 teachers participated, most of them attending 1 or 2 children and with a maximum of 16 children for one teacher (the mean was 1.87 children by teacher). The level of nesting at the previous analysed ages (5 and 10 years-old) was similar. The improvement achieved by adding school as a random factor was negligible. The intraclass correlation coefficient for the teacher's total SCDC scores at age 12 showed that the random factor explained only a 3.78% of the response variance. A likelihood ratio test against the non-multilevel model was non-significant ($\chi^2 = 1.29$, $p = .524$). The ICC's for ages 5 and 7 were also low (1.11% and 12.7% respectively). Given these results the multilevel approach was discarded because the common fit indices guiding the enumeration of classes in GMM models would hardly change (37).

Trajectories of SCDC

Bivariate correlations between the observed scores for both indicators over waves ranged from .16 to .69 (r values between parent and teacher ratings within follow-ups: .28 at the three ages, see Supplementary Table S1).

Table 2 shows the goodness-of-fit indices for the GMM models for one to four classes. Based on the aforementioned criteria, the 3-class model (Figures 1 and 2), which showed high entropy (.933) and adequate posterior probabilities of class membership ($\geq .866$), was selected.

Table 3 presents the parameter estimates for the selected 3-class model. The profile represented in the figures shows that class 1 ($n = 30$, 7.9%) included the children

whose parents reported some persistent mild difficulties throughout development and whose teachers considered them to be children with decreasing problems as they get older, until reaching a mild level of difficulties reported by both informants. Class 2 ($n = 40$, 10.6%) included the children that presented low difficulties as reported by the parent, but constant increasing difficulties from preschool to adolescence as reported by teachers. Class 3 ($n = 308$, 81.5%) included most of the sample and represented children with stable low difficulties as reported by parents and teachers in the SCDC scores from preschool to adolescence.

Trajectories of SCDC as predictor of clinical outcomes at age 12

Table 4 shows the comparison between the three classes for the demographical outcomes and the set of categorical outcomes analyzed. When compared with class 3, the adolescents represented in classes 1 and 2 presented with more professional psychological consultations and treatment, while class 1 had a higher percentage of ODD and disruptive disorders and more problems making friends.

Table 5 shows the results of comparing continuous outcomes at age 12 among the three classes. With respect to class 3, which includes children with a stable lack of problems, both classes 1 and 2 had lower global functioning and higher aggressive behavior, with effect sizes mainly high. The total callous-unemotional score was significantly higher in class 2 than in classes 1 and 3, with the effect size for the comparison with class 3 being bigger.

Regarding the DSM-oriented measures obtained from the CBCL, class 1 presented higher oppositional and anxiety scale scores than class 3, and a higher oppositional scale score than class 2. Effect sizes ranged from medium to high. Regarding the empirically-based CBCL scores, and in comparison with class 3, higher scores can be observed in anxious-depressed, social, and attention problems, rule-

breaking and aggressive behavior, externalizing, and total problems for class 1, and higher scores in somatic complaints, attention problems, aggressive behavior, externalizing, and total problems can be observed for class 2. Classes 1 and 2 differed between them regarding somatic complaints and rule-breaking behavior, with higher scores for class 1. Most effect sizes were medium to high, with the largest effect size obtained when comparing class 1 vs 3.

The analysis of the teacher's responses to the SDQ showed significant differences between classes 1 and 2 vs 3 in all the derived scores, being lower for the normative class 3. Effects sizes are in general high. Additionally, class 2 presents higher scores than class 1 in conduct problems, prosocial behavior, total difficulties, and externalizing problems, with effect sizes from medium to high.

Last, parents' SDQ scores were higher in classes 1 and 2 vs 3 for hyperactivity-inattention, total difficulties, and externalizing problems. Moreover, class 1 also scored higher than class 3 in peer problems and prosocial behavior. All except one of the effect sizes were high.

Discussion

This longitudinal study examines the developmental trajectories of social cognition, including information from different informants about a community sample aged 5 to 12 years, and tests whether relevant individual variables discriminate between the trajectories obtained. Three different trajectories were identified: one with children with persistent mild difficulties for parents and severe problems in the preschool period decreasing to a mild problematic level in adolescence for teachers (constant problems); a second one with children that present mild and constant difficulties as reported by parents and constant increasing difficulties for teachers (school increasers); and a last

one stably free of difficulties (normative). The three classes enabled us to discriminate between groups clinically differentiable groups.

The pattern of trajectories suggests that there are different paths of evolution from preschool to adolescence, supporting previous work that identifies adolescence as a critical period of change and development (9)(8). The class with children free of difficulties was the normative group (81%), as would be expected in a general sample. No differences as regards sex and socioeconomical status were found in the composition of the trajectories. In line with expectation, higher levels of psychological problems, as indicated by the significantly greater number of professional consultations and psychological treatments, and poorer daily functioning, were related to the likelihood of following the increasing or persistently mild problematic trajectories at school. Additionally, persistently problematic children as observed by both informants (7.9%) had an associated major probability of presenting disruptive DSM-5 diagnoses, specifically ODD and problems making friends. This finding is consistent with many previous studies (38) (39) (40), which have found an association between neurodevelopmental and disruptive problems and deficits in SC. Those with constant problems also present difficulties with keeping friends as time goes by. (41), found that difficulties in understanding other's feelings or emotions and the right interpretation of social clues are related to less classroom popularity and less consideration of maturity by teachers given that these are children that more frequently lie or manipulate. Furthermore, both non-normative classes included adolescents with higher scores in aggressive behavior. In the literature, aggressive conduct has been associated with bias or deficits in the processing of social clues (42).

As regards the differences between the two non-normative classes, the class that includes adolescents with school increasing difficulties seems to have a tougher way of

relating socially when compared with the adolescents in the persistently mild trajectory. They present more callousness traits, more total number of problems as informed by parents in a conduct checklist, and more conduct problems, prosocial difficulties, and general and externalizing difficulties as reported by teachers. Callousness traits distinguish children with more severe conduct problems, an interpersonal and affective style with lack of empathy and guilt, and emotional restrictive expression (43). Children with externalizing problems usually infer meaning to ambiguous contexts, are more prone to choose aggressive solutions to conflicts, and present more difficulties in anger regulation (44). These associations have been found to be more consistent with age, specifically after middle childhood (45), as is the case with class 2 (school increasers). On the other hand, persistently mild problematic children show more somatic complaints, meaning that difficulties with social relationships could be due to a more anxious pattern of behavior. SC difficulties have also been associated with social anxiety and the risk of social rejection in adolescence (4)(46). Children in this trajectory showed higher DSM anxiety scale scores when compared to both the normative class and the adolescents included in the class with increasing problems in school.

Much more variability in the teachers' information than in the parents' can be observed in the composition of the trajectories, indicating the relevance of including both informants in the assessment processes since the differences could indicate the source-specific information about SC that each informant can report. Teachers detect more social difficulties as children grow up. They can observe their interactions with the whole group of peers and not just with those who are most similar or related to the child, who may visit the child at home, or who the parents might know better because they have closer relationships with their offspring.

This study has the strength of being based on a large longitudinal sample and, as far as we know, is the first to trace trajectories derived from information based on two different informants, as usually happens in clinical settings. It is also important to highlight the fact that we found a significant association between SC trajectories and outcomes even when past outcomes were controlled.

The control of pubertal development stage is also a relevant key aspect. Some limitations are the fact that only disruptive disorders were assessed by the structural interview and the underrepresentation of children from the lower social classes.

This study suggests new ideas to rigorous research on the prevention and treatment of problems related to SC deficits. Most of the programs considered to be effective in the treatment of conduct problems are centered on behavior modification. Our results speak out about the suitability of including strategies for the development of SC beyond the areas of autistic spectrum disorders.

More research on the risk factors involved in each of the two non-normative classes may have clinical implications, helping to improve detection and differentiate the treatment of children with SC deficits but with different outcomes.

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