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The role of mother's prenatal substance use disorder and early parenting on child social cognition at school age

Marjo Susanna Flykt[1,2] | Jallu Lindblom[1] | Ritva Belt[3]† | Raija-Leena Punamäki[1]

[1]Faculty of Social Sciences, Tampere University, Tampere, Finland

[2]Faculty of Medicine, University of Helsinki, Helsinki, Finland

[3]City of Tampere, Finland

Correspondence
Marjo Susanna Flykt, Faculty of Social Sciences, Tampere University, Tampere, Finland

Faculty of Medicine/Psychology, University of Helsinki, Helsinki, Finland.
Email: marjo.flykt@tuni.fi, marjo.flykt@helsinki.fi

Abstract

This prospective longitudinal study examined how maternal prenatal substance use disorder (SUD) and early mother–infant interaction quality are associated with child social cognition (emotion recognition and mentalization) at school age. A sample of 52 poly-substance-using mothers receiving early interventions and 50 non-users, along with their children, was followed from pregnancy to school age. First-year mother–infant interaction quality was measured with EA scales. At school age, child facial emotion recognition was measured with DANVA and mentalization with LEAS-C. SUD group children did not differ from comparison children in social cognition, but higher severity of maternal prenatal addiction predicted emotion recognition problems. High early mother–infant interaction quality predicted better emotion recognition and mentalization, and mother–infant interaction quality mediated the effect of prenatal SUD on emotion recognition. The results highlight the need for early treatments targeting both parenting and addiction, as well as long-term developmental support for these children.

† Ritva Belt is now retired.

Highlights

- We examined how mother's prenatal substance use disorder (SUD) and early mother–infant interaction predict child social cognition at school age.
- Questionnaires, observational and computer tasks were used. Maternal prenatal addiction severity and early parenting problems predicted problematic child social cognition.
- Early interventions should simultaneously target addiction and parenting. Attention should also be paid to the long-term developmental support of children.

KEYWORDS
emotion recognition, mentalization, mother–infant interaction, school age, social cognition, substance use disorder

1 | INTRODUCTION

Social cognition refers to the array of processes children use for assessing and interpreting social information to navigate relationships (Frith & Frith, 2012; Pennington, 2000). Two of social cognition's core aspects include *emotion recognition*, that is, the basic ability to process and identify emotions from perceptual cues such as facial expressions, and *mentalization*, that is, higher order meta-cognitive awareness of both one's own and others' mental states (i.e., emotions, cognitions and intentions) as mechanisms underlying observable behaviour. Both capacities are vital for adaptive social functioning and mental health (Caputi, Lecce, Pagnin, & Banerjee, 2012; Collin, Bindra, Raju, Gillberg, & Minnis, 2013). Although deficits in social cognition often underlie adult substance use disorders (SUDs) (Castellano et al., 2015; Sanvicente-Vieira et al., 2017), little is known about the development of social cognition in the children of mothers with SUDs. Maternal prenatal SUD is accompanied by a variety of biological and psychosocial risks that may also predispose children to mental health and substance use problems (Koponen et al., 2020; Minnes et al., 2014). Deficits in social cognition are an important topic of study because they may precede the development of mental health and substance use problems.

Social cognition develops in the context of early parent–child relationships (Dykas & Cassidy, 2011; Fonagy, Bateman, & Lyuten, 2012), which are often found disturbed in dyads with maternal SUD (Parolin & Simonelli, 2016). Longitudinal studies are lacking on the role of both maternal SUD and early mother–infant interaction on children's social cognition. Finally, the severity of maternal addiction may play a role in a child's socioemotional outcome, including social cognition, but studies are lacking. Our study examines the relative contributions of maternal prenatal SUD—including addiction severity—and early mother–infant interaction quality during the first year on the development of children's social cognition (emotion recognition and mentalization) at school age.

1.1 | Mother's prenatal SUD as a context of cumulative developmental risk

Fetal drug exposure leads to maladaptive changes in brain structure and functional connectivity in various areas that are important for cognitive and socioemotional development (Gautam, Warner, Kan, & Sowel, 2015; Salzwedel et al., 2015), including social cognition (Homer & Solomon, 2008; Lindinger et al., 2016). Fetal exposure may also lead to infant health problems, such as prematurity and withdrawal symptoms (Minnes, Lang, & Singer, 2011; Salo & Flykt, 2013), and problems in self-regulation and social behaviour, such as increased crying or passivity (Lin, Ostlund, Conradt, Lagasse, & Lester, 2018).

Mothers with prenatal SUD often experience severe, cumulative psychosocial risks, including socioeconomic difficulties, single parenthood, mental health problems and interpersonal trauma history (Conners et al., 2004; Kaltenbach, 2013). These risks can especially interfere with optimal parenting resources: SUD mothers often show insensitive, poorly structured and intrusive-hostile features in early mother–infant interactions (Belt et al., 2012; Salo et al., 2010) or even direct maltreatment (Kepple, 2017). Maternal and infant vulnerabilities may create a negative feedback cycle, further exacerbating their interaction difficulties. This deprives infants of having maternal guidance in emotion recognition, expression and regulation, compromising their ability to learn and interpret others' behavioural intentions and social communication cues (Cicchetti, Rogosch, Maughan, Toth, & Bruce, 2003; Eiden, Godleski, Colder, & Schuetze, 2014; Pollak & Sinha, 2002), leading to problems in social cognition and ultimately to the risk of developmental psychopathology.

1.2 | Mother's prenatal substance use and child social cognition

Research is scarce on the role of maternal SUD for children's social cognition, so far focussing on maternal smoking and alcohol use. Concerning mentalization, preschool children prenatally exposed to smoking showed more difficulties in theory of mind tasks (i.e., the cognitive form of mentalization) than unexposed children (Reidy, Ross, & Hunter, 2013). Similarly, school-age children with fetal alcohol spectrum disorder (FASD) showed more difficulties in interpreting the mental states of others when compared with unexposed children (Greenbaum, Stevens, Nash, Koren, & Rovet, 2009; Lindinger et al., 2016). Less research exists on facial emotion recognition, but Greenbaum et al. (2009), as well as an unpublished doctoral dissertation (Siklos, 2008), both showed poorer facial emotion recognition and emotion processing among children with FASD. Finally, some research has indicated that rather than resulting in permanent impairment in social cognition, nicotine and alcohol exposure may lead to slower development of mentalization and emotion recognition among 4- to 8-year-olds but not younger or older children (Reidy et al., 2013; Siklos, 2008).

To the best of our knowledge, no studies exist on social cognition among children exposed to maternal prenatal illicit drug use. It is likely that exposure to illegal substances, such as opioids or amphetamine, also has similar harmful effects because in prenatally drug-exposed children, research has found anomalies in the neural networks related to social cognition. Studies have suggested that the frontal lobes, especially the prefrontal cortex, are vital for social cognition (Homer & Solomon, 2008). Salzwedel et al. (2015) showed that prenatal exposure to various drugs leads to connectivity disruptions within the amygdala–frontal, insula–frontal and insula–sensorimotor circuits in infancy. Jones and Davalos (2004) also found that children prenatally exposed to cocaine showed less empathic behaviour, along with frontal EEG asymmetry, which could potentially indicate problems in social cognition. Also, studies on adult SUD have shown that problems in social cognition are accompanied by neural deficits (Quednow, 2017), which persist despite the length of abstinence (Fernandez-Serrano, Lozano, Perez-Garcia, & Verdejo-Garcia, 2010), suggesting the importance of examining the role of maternal SUD on children's social cognition beyond the direct, biological exposure effects.

1.3 | Maternal addiction severity and child socioemotional development

In addition to prenatal exposure effects, maternal *addiction severity* may also affect children's socioemotional development. Addiction severity encompasses the extent of both *physical* and *psychological dependence* on the substance. Whereas physical dependence refers to withdrawal symptoms (e.g., nausea, headaches, sweating and tremors) and increased tolerance, psychological dependence implies the emotional and mental processes associated with the development and recovery from SUD (e.g., cravings or mood issues when not being able to use) (*American Addiction Centers*, https://americanaddictioncenters.org/the-addiction-cycle/psychological-dependence). *Harm from substances* that the person perceives physically, psychologically and socially is also inherently associated with the severity of addiction (Higgins-Biddle & Babor, 2018; Nutt, King, Saulsbury, & Blakemore, 2007).

Addiction severity has been associated with several factors that are known to be harmful for parenting and child development, such as maternal psychopathology and traumatic experiences both in childhood and adulthood (Cole, Sprang, & Silman, 2019; Gerra et al., 2014; Gossop, Marten, & Stewart, 2001). Both addiction severity and the number of childhood maltreatment experiences are also associated with impaired physiological stress regulation of the hypothalamus-pituitary-adrenocortical (HPA-) axis (Gerra et al., 2014). Furthermore, more severely addicted patients show more relapses and need more treatment cycles (Simoneau & Brochu, 2017; van Dam, Rando, Potenza, Tuit, & Sinha, 2014).

We could not find earlier studies on maternal addiction severity on children's social cognition. However, more severe addiction, as indicated by a higher amount and duration of use, has been associated with more emotion recognition problems in adults (Fernandez-Serrano et al., 2010). We could locate only two studies on the role of a mother's addiction on a child's socioemotional development, namely child mental health, which gave inconclusive results. In their population-based register study, Raitasalo, Holmila, Jääskeläinen, and Santalahti (2019) showed that maternal alcohol dependence, independent of its severity, was associated with increased behavioural and mental health symptoms in their adolescents. Hser, Evans, Li, Metchnik-Gaddis, and Messina (2014) showed in a 10-year follow-up study on mothers who had undergone drug abuse treatment that mothers' alcohol or drug addiction severity was not associated with children's mental health symptoms, but symptoms were explained by psychosocial risks. In the current study, we examine whether maternal addiction severity, as indicated by the mother's physical and psychological dependence on alcohol and drugs, as well as perceived harm from drugs, is associated with the development of a child's social cognition.

1.4 | Early mother–infant interaction and children's social cognition in high-risk families

Early parent–child relationship forms the most important context for the development of children's emotion recognition and mentalization. The mother's sensitive responsiveness to child signals and her adequate regulation and validation of the child's emotions are considered vital for the optimal development of a child's social cognition (Fonagy et al., 2012). However, inconsistent or frightening parenting characteristics that are prevalent in high-risk families may leave the child with an impoverished or biased understanding of their caregiver's and, subsequently, other people's emotions and behaviour (Cicchetti et al., 2003; Pollak & Sinha, 2002).

Most literature on the role of parenting on child emotion recognition has focussed on child maltreatment, which can be considered the most severe form of parent–child interaction disturbance. Most studies (for a review, see Luke & Banerjee, 2013; Assed et al., 2020) have indicated that maltreated children develop less accurate emotion recognition than children with more optimal caregiving. Maltreating and especially emotionally neglecting caregiving may present fewer learning opportunities when children's emotions are not labelled or responded to (McLaughlin, Sheridan, & Nelson, 2017). Similar findings on the association between higher parent–child relationship quality and a child's better emotion recognition have also been obtained in the context of maternal depression (Kujawa et al., 2014; Székely et al., 2014) and among normative children (Steele, Steele, & Croft, 2008). In the only existing longitudinal study from infancy to school age (Steele et al., 2008), infants' secure attachment during the first year predicted better emotion recognition at 6 and 11 years of age. A few studies also indicate that as an adaptation to dangerous environments or coping alone without parental support, children may also develop lower thresholds in recognizing certain salient emotions. Children with highly problematic early parenting and marital relationships in their families showed an enhanced ability to recognize negative emotions (Laamanen et al., 2021). Along similar lines, physically abused children were shown to over-recognize emotions as angry (Pollak & Sinha, 2002), whereas children of depressed mothers over-recognized them as sad (Lopez-Duran, Kuhlman, George, & Kovacs, 2013).

Concerning mentalization, the research is univocal in that children from both normative (Ensor, Spencer, & Hughes, 2011) and distressed caregiving contexts, such as maltreatment or maternal depression, show more problems in mentalization (Ensink, Bégin, Normandin, & Fonagy, 2016; Koizumi & Takagishi, 2014; Pears & Fisher, 2005; Raikes & Thompson, 2006). Fonagy et al. (2012) suggested that awareness of the caregiver's hostile emotions is too threatening; therefore, it is defensively shut out. Subsequently, these children are deprived of the capacity to use their own and others' emotions as a source of guidance. Also, the nature of the family environment can be decisive for learning specific types of mentalization. Fonagy et al. (2012) (see also Luyten & Fonagy, 2015) differentiated between self- and other-directed mentalization as two neurally separate but intertwined abilities of understanding one's own and other people's emotions and other mental states. Typically, maltreated children may become highly vigilant of others' emotions, especially negative ones but may not adequately learn to understand their own emotions, which have rarely elicited caregiver attention (Fonagy et al., 2012; Lambie & Lindberg, 2016).

1.5 | Maternal SUD, mother–infant interaction and social cognition: Cascading pathways

No previous research exists on the role of early mother–infant interaction in the development of children's social cognition in children with prenatal maternal SUD. Previous research has mainly focused on early childhood and cross-sectional designs (except for Steele et al., 2008). Long-term follow-ups would be vital here because early mother–infant interaction quality may be part of a cascading developmental pathway to child psychopathology or adaptation.

In terms of general socioemotional development throughout childhood and adolescence, in normative samples, substantial evidence is available on the protective role of optimal early parenting quality (Haltigan, Roisman, & Fraley, 2013; Raby, Roisman, Fraley, & Simpson, 2015). In samples with maternal SUD, Conners-Burrow et al. (2013) and Eiden et al. (2014) showed that maternal SUD itself did not increase the risk for children's mental health symptoms but did so only in conjunction with harsh parenting. Similarly, prenatal tobacco exposure predicted children's self-regulation problems only in the context of low maternal responsiveness (Clark, Massey, Wiebe, Espy, & Wakschlag, 2019). Early sensitive parenting may lead to positive developmental cascades that counteract the negative effects of fetal exposure to drugs. Among children in alcoholic families, early maternal sensitive responsiveness led to positive developmental cascades with higher social competence, less externalizing symptoms and lower substance use risk in adolescence (Eiden et al., 2016). The current study aims to shed light on the relative contributions and pathways between maternal prenatal SUD, including addiction severity, and early mother–infant interaction quality for the development of children's social cognition.

1.6 | Research questions and hypotheses

Our *first research question* is whether the children of prenatally treatment-enrolled mothers with SUD differ from the children of non-using mothers in their social cognition, including facial emotion recognition and mentalization. We further examine whether maternal *prenatal substance addiction severity* predicts children's emotion recognition and mentalization. We hypothesize that the SUD group children will show lower emotion recognition accuracy and poorer self- and other-directed mentalization than the children of non-using mothers. We further hypothesize that mothers' addiction severity, that is, higher physical and psychological dependence on alcohol and drugs, as well as perceived harm from drugs, will be associated with less accurate emotion recognition and poorer mentalization at school age.

Our *second research question* is whether early mother–infant interaction quality predicts social cognition at school age among the children of SUD and non-using mothers. We hypothesize that higher early mother–infant interaction quality will be associated with better facial emotion recognition accuracy and self- and other-directed mentalization at school age, despite maternal SUD. Finally, our *third question* is whether early mother–infant interaction quality mediates the effect of maternal SUD on children's social cognition. We hypothesize that the negative effects of maternal prenatal SUD will be mediated via the lower quality of mother–infant interaction, which then will predict poor emotion recognition accuracy and mentalization.

2 | METHODS

2.1 | Participants and procedure

The present prospective quasi-experimental study included four measurement points: pregnancy (T1), child age of 4 months (T2), child age of 12 months (T3) and child at school age (8–12 years, T4). The study group consisted of mothers with a diagnosed SUD (n = 52), all with a history of severe illegal drug or poly-substance misuse that had lasted for several years. The SUD mothers were recruited during the third (or in three cases, the second) trimester of pregnancy (mean gestational week: 34.61, SD 4.70) from two outpatient clinics in Southern Finland that were offering integrated parenting and SUD treatments. The comparison group consisted of mothers (n = 50) with no prenatal substance use, previous illegal drug use or alcohol misuse. They were recruited during the third trimester of pregnancy from a hospital outpatient clinic where they had contact because of pregnancy complications, such as gestational diabetes or preterm contractions.

In both clinics, the SUD mothers received comprehensive, multi-professional support, including help from social services and addiction and mental health counselling. For parenting support, they received either weekly 3-hour sessions of group-based mother–infant psychotherapy or home visits and other individually tailored support for 1–2 days a week. The interventions lasted for 9–12 months. Mother–infant interaction problems decreased during the first-year interventions (for more details about interventions and their effectiveness, see Belt & Punamäki, 2007; Belt et al., 2012). The first assessment (T1) took place prior to any interventions. Although the interventions may attenuate some effects of maternal SUD on child development, it would be ethically problematic to study this high-risk population without providing treatment when possible.

On average, SUD mothers had used eight different substances, the most common being cannabis, amphetamine, opioids, alcohol and misuse of prescription drugs. At T1, a majority (79.2%) reported intravenous use, and more than half (58.8%) reported alcohol use above the clinical cut-off ($\geq$3 for women) on the Alcohol Use Disorders Identification Test consumption scale (AUDIT-C). Almost a fourth (23.1%) were in buprenorphine replacement therapy throughout their pregnancy. At T1, 87.2% of SUD group mothers reported having stopped using drugs, and the remaining four mothers reported diminishing their use. According to the treating clinicians (who had access to urine test data), most mothers either stopped or diminished use after pregnancy recognition, typically in the second trimester. Thus, most mothers used substances heavily only during the first trimester although it was not uncommon for substance use to continue until the beginning of treatment. Four SUD group children showed opiate withdrawal symptoms at birth, all with mothers receiving buprenorphine replacement therapy. During the child's first year, 24.4% of the mothers (n = 10; 5 at T2 and 8 at T3) reported occasional drug relapses, and 9.5% (n = 4; 3 at T2 and 3 at T3) reported intravenous use.

No systematic treatment was offered to SUD mothers after the initial interventions, but according to the clinicians, many continued to have help, such as psychiatric or addiction counselling or help from social services. At T4, 55% of the SUD group mothers reported currently receiving help for addiction and/or mental health symptoms, including from addiction counselling or anonymous alcoholics (AA) groups (n = 6), mental health services (n = 7), psychiatric medication (n = 7) and buprenorphine replacement therapy (n = 4). Furthermore, at T4, 33.3% of the SUD group mothers reported total Alcohol Use Identification Test (AUDIT) scores above the clinical cut-off (≥7), and 10.5% reported illegal drug use during the past year. Yet, although 57.9% of SUD group mothers reported intravenous use between childbirth and T4 measurement, none reported it during the past year.

The participation rate at T2 was 92% (n = 48) for the SUD group and 86% (n = 43) for the comparison group; at T3, the participation rate was 73% (n = 38) for the SUD group and 78% (n = 39) for the comparison group. For T4, the participation rate was low for the SUD group, 38% (n = 20), whereas in the comparison group, it was 62% (n = 31). The rates differed significantly only at T4, with SUD mothers and their children having higher drop-out, $\chi^2(1) = 5.65$, $p = .02$. The T4 drop-out rate was, however, not related to any background characteristics, including marital status, $\chi^2(1) = 0.99$, $p = .32$, educational level, $\chi^2(2) = 5.59$, $p = .06$, economic difficulties, $\chi^2(1) = 3.24$, $p = .07$, mother's drug use at T2, Fisher exact test $p = .39$ or at T3, Fisher's exact test $p = .72$ or mother–infant interaction at T2, $t(81) = -1.35$, $p = .18$ or at T3, $t(76) = -1.55$, $p = .13$.

For T4 recruitment, the contact information of previously participating mothers was obtained from the Finnish population registry, and the mothers were recontacted with a letter. Those interested in participating phoned the researchers or returned a written consent form that allowed the researcher to call them. The researchers explained the study procedure in detail over the phone, and the mothers were also instructed to describe the study to their children and ask their permission to participate. Eight mothers in the SUD group could not be reached: three had died, and five had no permanent address. The rest refused or did not return the form. In eight cases (three SUD and five comparisons), the mother participated without the child. Two comparison mothers had twins, and data from one (randomly selected) twin were used in the analyses. Six of the SUD group children were in foster care, and with permission from the biological mother, the foster mothers were also contacted. Three foster mothers participated together with the biological mothers, and in one case, only the foster mother participated.

At T4, a licensed psychologist met the SUD and comparison group mothers and children at their homes or open clinic settings, based on their preferences. Before the assessment, both the mother and child received detailed verbal and written information about the study and signed an informed consent form. During the visit, the mother filled out a questionnaire while the psychologist conducted an individual assessment with the child, including computerized and individual testing and questionnaires, which were read aloud if necessary. The study procedure was accepted by the ethical boards of the local hospital districts at T1–T4 and also by the municipal clinics where the participants were recruited at T1–T3. The study conforms to the ethical standards of the Declaration of Helsinki.

2.2 | Measures

2.2.1 | Background variables

The demographic factors at T1 were reported by mothers on a questionnaire, including gestational week when enrolled in the study (for the SUD group, this also signified the beginning of intervention), number of children, mother's marital status (dichotomized into 'married/cohabiting' vs. 'single'), educational level (dichotomized into 'high school or lower' vs. 'college or other education after high school') and economic difficulties (Yes/No). At T2, the mothers further reported about child sex, neonatal health problems (Yes/No) and birth weight.

2.2.2 | Maternal substance use variables

The mothers reported at T1–T3 on the drugs they had used, intravenous use and buprenorphine replacement therapy. At T1, they also reported whether they currently had stopped their drug use, diminished it or whether it remained the same or had increased. *Maternal prenatal addiction severity* was indicated by the T1 AUDIT scores (Saunders, Aasland, Babor, de la Puente, & Grant, 1993) (scores on consumption and dependence scales, scale: 0–4), their self-reported physical and psychological dependence on drugs (scale: 1–5, 1 = no dependency and 5 = complete dependency), and whether they perceived their use as harmful (No/Yes). *Maternal postnatal use* was indicated by a combination of self-reported drug relapses at T2 and T3 (No/Yes). At T4, maternal alcohol use was measured with the AUDIT (Saunders et al., 1993). At T4, the mothers also reported illegal drug use during the past year, intravenous use after the child was born and during the past year and buprenorphine replacement therapy.

2.2.3 | Mother–infant interaction quality

This was measured at T2 and T3 using the EA scales, fourth edition (Biringen, 2008). The mother was asked to play with the infant as they usually would, and a 10–15 minute free-play interaction was videotaped. Only maternal scales were used because the child scales were not theoretically expected to associate with the outcome variables. They comprise *maternal sensitivity* (i.e., positive emotional expression and adaptive reactions toward the child), *maternal structuring* (i.e., guiding and scaffolding the child in a developmentally appropriate way), *maternal non-intrusiveness* (i.e., ability to refrain from negatively interfering, overstimulating or overprotecting the child) and *maternal non-hostility*, which is indicative of the ability to regulate one's negative affect expression. All scales were coded on a 7-point Likert scale (1–7, with .5 being possible codes) by two reliable coders who were blind to maternal group status and background information. Inter-rater reliabilities (Pearson's *r*) ranged between .82 and .97 at T2 and between .85 and .97 at T3. An average composite scale from all the maternal dimensions at both time points was used to indicate early maternal EA. A composite scale was chosen to decrease the number of variables in the analyses because of the small sample size while at the same time withholding as much information as possible because all the scales differed between SUD and comparison mothers (see Belt et al., 2012). Different EA scales have high intercorrelations, and using composite scales has been described as typical and appropriate in the EA literature (for a review, see Biringen, Derscheid, Vliegen, Closson, & Easterbrooks, 2014).

2.2.4 | T4 child emotion recognition

This was measured with the computerized version of Diagnostic Analysis of Nonverbal Accuracy 2: Child Facial Expressions (DANVA-2-CF; Nowicki, 2006; Nowicki Jr. & Carton, 1993). The test consists of 24 photographs of child facial expressions (12 male, 12 female) showing an equal number of high- and low-affective intensity displays of happy, sad, angry and fearful faces. The children were instructed to select the verbal emotion label that best matched the facial expression they saw on the screen. The photographs were presented for 2 seconds, and the children had as much time as needed to select one of the four labels using a computer mouse. At the beginning of the task, the children did an interactive practice task and heard prerecorded instructions played by the computer. The researcher was also available for assistance if needed. If the child could not answer, s/he was instructed to 'choose the one that would be the best guess'. Two separate summary scores were computed for *low-intensity*, that is, difficult to recognize (max 12 points), and *high-intensity*, that is, easily recognizable (max 12 points) emotions by summing the total correct answers separately for both intensities. Finally, the *emotion-specific accuracy scores* were computed separately for each emotion (happiness, sadness, anger and fear) by calculating a sum of the correct answers for each emotion (max 6).

2.2.5 | T4 child mentalization

This was measured using the Levels of Emotional Awareness Scales for Children (LEAS-C; Bajgar, Ciarrochi, Lane, & Deane, 2005), which measures affective mentalization. LEAS-C is a modification of an adult version, LEAS

(Lane, 1991). It consists of 12 scenarios, each involving the child and another person. The scenarios were read aloud to the children, and after each one, they were asked to answer the following questions: ‘How would you feel?’ and ‘How would the other person feel?’ The answers were videotaped and scored by two blinded coders. Each scenario was rated separately for the self and the other person (range 0–4 on a Likert scale, total maximum of 48). The complexity of explicit emotion words was scored, not whether the emotions were ‘correct’ for the situation. Low scores reflect non-emotional responses (e.g., ‘I would feel sick’), whereas high scores reflect complex descriptions with emotion blends (e.g., ‘I would feel angry, but also somewhat sad’). Inter-rater reliability (Pearson's r) for 21% of the cases (n = 10) was .85 for the self-directed scale and .97 for the other-directed scale. Differences were negotiated between the coders and the first author.

2.3 | Statistical analyses

Descriptive analyses included examining the associations of background variables (number of children, mother's marital status, educational level, economic difficulties, child sex, neonatal health problems and birth weight) with (a) maternal SUD/comparison group status and (b) the main study variables: maternal EA during the first-year and school-age children's emotion recognition (including emotion-specific recognition of anger, sadness, fear and happiness) and, separately, intensity-specific recognition, that is, total recognition of low- versus high-intensity emotions, along with self- and other-directed mentalization. Additionally, we tested whether maternal first-year EA differed between the SUD and comparison groups. Further, for SUD mothers only, we examined whether the gestational age when the mother started the intervention (T1) and occurrence of postnatal drug relapses (T2 + T3) were associated with the main study variables. Finally, we reported how maternal prenatal addiction severity variables (T1 alcohol consumption and dependence, physical and psychological drug dependence and perceived harm from drugs) were associated with the above-mentioned background variables in the SUD group. Chi-square tests/Fisher's exact tests, student's t-tests and Pearson's correlations were used for descriptive analyses based on whether the variables were categorical or continuous.

To answer our research questions, Mplus version 8 (Muthén & Muthén, 1998–2017) was used. Little's MCAR test showed that missingness in the data occurred completely at random, p = .88. Therefore, the missing values were handled using the full information maximum likelihood (FIML), which is known to be more reliable than listwise deletion with high levels of missingness (Graham, 2009). Collins, Schafer, and Kam (2001) and Graham (2003) recommend that in the case of high missingness (>50%), FIML with auxiliary variables (i.e., variables that correlate with at least .40 with the study variables) should be used to reliably correct for missingness. Therefore, 10 additional variables (e.g., child development and soothability at 12 months) from T1–T3 that correlated highly (>.40) with the study variables were used as auxiliary variables. MLR was used as the estimation method.

To answer our first research question about the differences between the SUD and comparison groups in social cognition (emotion recognition and mentalization), three separate regression models were built, with the maternal SUD group versus comparison group as a dichotomous predictor. In the first, the accuracy scores for high-intensity emotions and low-intensity emotions were used as the dependent variables. In the second, the accuracy scores for emotion-specific recognition of sad, angry, fearful and happy expressions were the dependent variables. In the third, child self- and other-directed mentalization was used as dependent variables. Furthermore, we then separately looked at the association between maternal addiction severity variables on the same sets of outcome variables by constructing a set of models for T1 alcohol use (AUDIT consumption and AUDIT dependence) and another one for T1 illegal drug use (physical and psychological drug dependence and perceptions of harm from drugs).

To answer our second question regarding the first-year maternal EA being associated with child social cognition in the SUD and comparison groups, we analysed its effect on child emotion recognition and mentalization in three different regression models by using the same outcome variables as in the first research question. We conducted the analysis both with and without maternal SUD group status in the model. Third, we used three mediation analyses to examine whether maternal EA mediated the effect of SUD on child emotion recognition, here separately for (1) the recognition of low- or high-intensity stimuli, (2) emotion-specific recognition and (3) child mentalization. Mediation analyses were based on the delta method in Mplus (Muthén & Muthén, 1998–2017).

All regression analyses involved child age, maternal educational level, marital status and economic problems as covariates. Child age has been found to be associated with better social cognition (Herba, Landau, Russell, Ecker, & Phillips, 2006), and the age range in our sample varied between 8 and 12 years at T4. Other covariates were based on preliminary results from descriptive analyses. Benjamini–Hochberg corrections were performed to account for the total number of statistical analyses related to SUD, addiction severity and EA variables, and adjusted *p*-values (p_{adj}) were used for statistical inferences.

3 | RESULTS

3.1 | Descriptive statistics

Table 1 shows the differences in background variables and EA between maternal SUD and comparison group dyads. The results showed that the SUD group differed from the comparison group in lower maternal educational levels, more economic difficulties and mothers as being more likely to be single parents. The SUD mothers also showed

TABLE 1 Differences in the background variables and maternal EA in the SUD and comparison groups

	SUD		**Comparison**			
	n	**%**	***n***	**%**	**$\chi^2(1)$**	***p***
Mother's marital status					18.31	**<.001**
Married or cohabiting	28	57.1%	47	94%		
Single	21	42.8%	3	6%		
Mother's educational level					27.43	**<.001**
Lower	47	94%	23	46%		
Higher	3	6%	27	54%		
Economic difficulties					21.17	**<.001**
Yes	37	72%	14	26%		
No	13	28%	36	74%		
Child sex					0.84	.36
Girl	17	37%	20	46.5%		
Boy	29	63%	23	53.5%		
Neonatal health problems					2.05	.15
No	29	76.3%	38	88.4%		
Yes	9	23.7%	5	11.6%		
	M	SD	*M*	SD	*t*(df)	*p*
Number of children	0.84	0.87	0.86	1.16	.11 (97)	.91
Infant birth weight	3,502.08	450.66	3,444.90	793.16	−0.39 (78)	.70
Maternal first year EA	4.10	0.83	5.04	0.86	5.34(89)	**<.001**

Note: Differences in '*n*' are because of missing values in some of the variables.
Abbreviations: SUD, substance use disorder.

TABLE 2 Emotion recognition at school age in children with maternal prenatal SUD and comparison children

	Anger recognition					Sadness recognition					Fear recognition					Happiness recognition				
	β	*SE*	CI	*p*	p_{adj}[a]	*β*	*SE*	CI	*p*	p_{adj}[a]	*β*	*SE*	CI	*p*	p_{adj}[a]	*β*	*SE*	CI	*p*	p_{adj}[a]
SUD	.25	.19	[−.12, .62]	.19	.27	.08	.21	[−.33, .50]	.69	.66	−.29	.22	[−.72, .15]	.17	.25	−.39	.22	[−.82, .05]	.08	.16
Child age	.20	.14	[−.08, .48]	.17		.29	.15	[.004,.58]	**.047**		−.25	.16	[−.57, .06]	.11		−.19	.16	[−.50, .13]	.25	
Educational level	−.13	.15	[−.43, .17]	.40		.04	.15	[−.25, .33]	.78		−.07	.16	[−.37, .24]	.66		−.18	.13	[−.45, .08]	.17	
Economic problems	−.32	.15	[−.61, −.03]	**.03**		−.05	.17	[−.37, .28]	.78		.03	.15	[−.27, .32]	.86		.13	.18	[−.23, .49]	.48	
Marital status	−.30	.13	[−.55, −.05]	**.018**		−.06	.16	[−.37, .26]	.73		.01	.15	[−.29, .30]	.98		.27	.17	[−.06, .59]	.11	
	R^2 = .24*					R^2 = .07					R^2 = .08					R^2 = .12				

	Total high-intensity recognition					Total low-intensity recognition				
	β	*SE*	CI	*p*	p_{adj}[a]	*β*	*SE*	CI	*p*	p_{adj}[a]
SUD	.16	.18	[−.19, .50]	.37	.42	−.11	.20	[−.50, .29]	.60	.59
Child age	.18	.17	[−.14, .50]	.28		.05	.16	[−.26, .35]	.77	
Educational level	−.08	.13	[−.34, .17]	.52		−.10	.16	[−.42, .22]	.55	
Economic problems	−.10	.15	[−.39, .18]	.48		−.21	.15	[−.50, .08]	.16	
Marital status	−.26	.16	[−.57, .04]	.09		−.02	.15	[−.32, .27]	.88	
	R^2 = .08					R^2 = .05				

Note: CIs refer to 95% confidence intervals. Comparison = 1, SUD = 2. *p < .05.

Abbreviations: SUD, substance use disorder.

[a] *p*-values for SUD variables were adjusted with Benjamini–Hochberg correction to take into account the number of analyses.

lower EA during the child's first year than the comparison mothers. There was no difference in child sex, neonatal health problems, birth weight or number of children.

Appendices A1–A3 in Data S1 show the associations of the background variables with maternal EA and child social cognition variables. Lower maternal educational level was associated with lower maternal EA during the first year, $t(89) = -2.90$, $p = .005$. Economic difficulties, $t(40) = 2.45$, $p = .019$, and neonatal health problems, $t(36) = -2.37$, $p = .023$, were associated with higher child anger recognition. A higher number of children was associated with better child self-directed mentalization, Pearson's $r = .35$, $p = .038$. No differences were found in other variables, including the gestational week the mother started the intervention or postnatal relapses, which were examined in the SUD group only.

Appendices A4–A6 in Data S1 show the associations of maternal prenatal addiction severity variables with the background variables in the SUD group. Higher reported physical drug dependence at T1 was associated with being married/cohabiting, $t(38) = 2.74$, $p = .009$, and having economic problems, $t(39) = 3.23$, $p = .003$; it was also associated with neonatal health problems, $t(8.62) = -2.98$, $p = .048$. Higher reported alcohol consumption at T1 was associated with a higher occurrence of post-natal drug relapses, $t(36) = -2.05$, $p = .048$.

3.2 | Maternal prenatal SUD and child social cognition at school age

Our first question was whether children in the SUD and comparison groups would differ in social cognition, as indicated by emotion recognition and mentalization. As shown in Table 2, concerning both intensity-specific and emotion-specific recognition accuracy, the results did not support our hypothesis, showing no differences between the SUD and comparison groups. Similarly, as shown in Table 3, SUD group status was not associated with children's mentalization.

The results regarding the role of maternal prenatal addiction severity in predicting child social cognition are shown in detail in the Appendix A7 and A8 in Data S1. Mothers' alcohol consumption and dependence, psychological drug dependence and perceived harm from drugs were associated with children's emotion recognition. In more detail, regarding *alcohol use*, the mother's higher *prenatal alcohol dependence* predicted the child's poorer recognition of low-intensity emotions, as hypothesized, $\beta = -.42$, SE = .15, 95% CI [−.72, −.13], $p_{adj} = .02$. Curiously, and against our hypothesis, higher *alcohol consumption* predicted a child's better recognition of anger, $\beta = .34$, SE = .13, 95% CI [.09, .59], $p_{adj} = .03$, and low-intensity emotions, $\beta = .33$, SE = .13, 95% CI [.08, .58], $p_{adj} = .04$. Regarding *drug use*, as hypothesized, mother's *perceived harm from drugs* predicted the child's poorer high-intensity emotion recognition,

TABLE 3 Mentalization at school age in children with maternal prenatal SUD and comparison children

	Self-directed mentalization					Other-directed mentalization				
	β	*SE*	CI	*p*	p_{adj}[a]	β	*SE*	CI	*p*	p_{adj}[a]
SUD group[a]	−.15	.20	[−.55, .25]	.46	.48	−.37	.22	[−.81, .06]	.09	.16
Child age	.05	.13	[−.21, .30]	.72		−.20	.15	[−.51, .10]	.19	
Educational level	.28	.15	[−.01, .59]	.055		−.06	.22	{−.49, .37]	.78	
Economic problems	−.34	.16	[−.65, −.03]	**.03**		−.19	.19	[−.55, .18]	.31	
Marital status	.27	.14	[−.002, .55]	.052		.13	.19	[−.23, .50]	.48	
	$R^2 = .21$*					$R^2 = .09$				

Note: CIs refer to 95% confidence intervals. Comparison = 1, SUD = 2. *$p < .05$.
Abbreviations: SUD, substance use disorder.
[a]*p*-values for SUD variables were adjusted with Benjamini–Hochberg correction to take into account the number of analyses.

TABLE 4 Mother's emotional availability during the child's first-year and child emotion recognition at school age

	Anger recognition					Sadness recognition					Fear recognition					Happiness recognition				
	β	*SE*	CI	*p*	p_{adj}[a]	β	*SE*	CI	*p*	p_{adj}[a]	β	*SE*	CI	*p*	p_{adj}[a]	β	*SE*	CI	*p*	p_{adj}[a]
EA	.16	.15	[−.14, .45]	.31	.39	.39	.09	[.22, .56]	**<.001**	**<.001**	.35	.13	[.10, .60]	**.005**	**.02**	.25	.13	[.003, .50]	**.047**	.11
Child age	.14	.11	[−.07, .35]	.20		.29	.13	[.03, .54]	**.029**		−.12	.12	[−.35, .11]	.31		−.02	.14	[−.29, .25]	.90	
Educational level	−.12	.16	[−.42, .19]	.45		.04	.13	[−.20, .29]	.73		.02	.15	[−.27, .30]	.91		−.03	.13	[−.30, .23]	.80	
Economic problems	−.46	.13	[−.71, −.20]	**<.001**		−.15	.13	[−.41, .10]	.23		.02	.14	[−.26, .29]	.90		.15	.17	[−.18, .47]	.37	
Marital status	−.19	.13	[−.44, .06]	**.13**		.01	.12	[−.22, .24]	.95		−.06	.12	[−.30, .18]	.61		.21	.14	[−.07, .49]	.15	
	R^2 = .22*					R^2 = .24*					R^2 = .14					R^2 = .11				

	Total high-intensity recognition					Total low-intensity recognition				
	β	*SE*	CI	*p*	p_{adj}[a]	β	*SE*	CI	*p*	p_{adj}[a]
EA	.25	.12	[.01, .50]	**.041**	.10	.43	.11	[.22, .64]	**<.001**	**<.001**
Child age	.23	.13	[−.03, .48]	.08		.06	.12	[−.18, .30]	.62	
Educational level	−.02	.15	[−.31, .27]	.90		−.07	.15	[−.36, .22]	.64	
Economic problems	−.28	.12	[−.51, −.05]	**.017**		−.24	.13	[−.49, .01]	.06	
Marital status	−.15	.15	[−.45, .15]	.31		−.02	.12	[−.26, .22]	.88	
	R^2 = .16*					R^2 = .20*				

Note: CIs refer to 95% confidence intervals. *$p < .05$.
Abbreviations: EA, mother's emotional availability during the first year.
[a]*p*-values for EA variables were adjusted with Benjamini–Hochberg correction to take into account the number of analyses.

TABLE 5 Mother's emotional availability during the child's first-year and child mentalization at school age

	Self-directed mentalization					Other-directed mentalization				
	β	*SE*	95% CI	*p*	*Corr.* p_{adj} [a]	β	*SE*	95% CI	*p*	*Corr.* p_{adj} [a]
EA	.38	.11	[.16, .60]	**.001**	**.005**	.41	.16	[.09, .73]	**.012**	**.04**
Child age	.01	.11	[−.21, .23]	.93		−.09	.13	[−.34, .16]	.47	
Educational level	.25	.13	[−.01, .50]	.06		.02	.18	[−.33, .37]	.92	
Economic problems	−.31	.15	[−.61, −.01]	**.045**		−.14	.18	[−.49, .21]	.43	
Marital status	.23	.13	[−.01, .48]	.06		.04	.17	[−.28, .37]	.79	
	R^2 = .29**					R^2 = .17				

Note: CIs refer to 95% confidence intervals. $^{**}p < .01$.
Abbreviations: EA, mother's emotional availability during the first year.
[a]*p*-values for EA variables were corrected with Benjamini–Hochberg correction to take into account the number of analyses.

β = −.80, SE = .13, 95% CI [−1.06, −.54], p_{adj} < .001, and poorer recognition in all emotion-specific areas: anger, β = −.48, SE = .15, 95% CI [−.77, −.18], p_{adj} = .005; sadness, β = −.60, SE = .16, 95% CI [−.91, −.29], p_{adj} < .001; fear, β = −.74, SE = .20, 95% CI [−1.12, −.36], p_{adj} < .001 and happiness, β = −.61, SE = .17, 95% CI [−.95, −.26], p_{adj} < .001. Curiously, and against our hypothesis, higher maternal prenatal psychological drug dependence was associated with the child's better recognition of high-intensity emotions, β = .55, SE = .19, 95% CI [.19, .91], p_{adj} = .02. Contrary to our hypothesis, the maternal addiction severity variables were not associated with child mentalization.

3.3 | The role of early mother–infant interaction on social cognition

Our second question was whether early mother–infant interaction quality was associated with child social cognition at school age. The results partially supported our hypothesis on the beneficial effect of high early mother–infant interaction quality predicting good child emotion recognition. Table 4 shows that concerning emotion-specific recognition, higher early maternal EA predicted a child's more accurate recognition of sadness and fear. Concerning intensity-specific recognition, higher early maternal EA predicted a child's more accurate recognition of low-intensity emotions. When maternal SUD was added to the emotion-specific model (see Appendix A9 in Data S1), EA remained significant only on sadness recognition, β = .54, SE = .12, 95% CI [.31, .77], p_{adj} <. 001. Further, when maternal SUD was added to the intensity model, EA remained significant for low-intensity recognition, β = .50, SE = .14 95% CI [.22, .78], p_{adj} = .005.

As shown in Table 5, concerning mentalization, the results were in line with our hypothesis. Mothers' higher early EA was associated both with children's higher self- and other-directed mentalization. When maternal SUD was added to the model (see Appendix A10 in Data S1), the results remained only for self-directed mentalization, β = .44, SE = .16, 95% CI [.12, .75], p_{adj} = .03.

3.4 | The mediating role of mother–infant interaction between SUD and social cognition

Our third question was whether early mother–infant interaction quality mediates the effect of maternal SUD on children's social cognition. As hypothesized, the results showed that early maternal EA mediated the effects of maternal

SUD on child recognition of low-intensity emotions, $\beta = -.24$, SE = .07, 95% CI [−.39, −.10], $p_{adj} = .005$, and sadness, $\beta = -.26$, SE = .07, 95% CI [−.39, −.13], $p_{adj} < .001$. In other words, maternal SUD predicted low maternal EA, which subsequently predicted children's poorer recognition of low-intensity emotions and sadness. Yet, mediation was not significant on high-intensity recognition, $\beta = -.17$, SE = .08, 95% CI [−.33, −.02], $p_{adj} = .08$, or on recognition of other emotions, anger: $\beta = -.13$, SE = .08, 95% CI [−.28, .02], $p_{adj} = .17$; fear: $\beta = -.15$, SE = .10, 95% CI [−.34, .05], $p_{adj} = .22$ or happiness: $\beta = -.07$, SE = .08, 95% CI [−.28, .02], $p_{adj} = .46$. Concerning mentalization, early maternal EA did not mediate the effects of maternal SUD on either the child's self-directed, $\beta = -.21$, SE = .09, 95% CI [−.38, −.04], $p_{adj} = .06$, or other-directed mentalization, $\beta = -.17$, SE = .11, 95% CI [−.23, .09], $p_{adj} = .20$.

4 | DISCUSSION

Maternal prenatal SUD presents multi-level, cascading risks for a child's socioemotional development, including the child's social cognition, a central capacity for social information processing and emotional adaptation. Our prospective longitudinal study followed a sample of treatment-enrolled, high-risk mothers with prenatal SUD and their children from pregnancy into school age. Our main findings highlight the potential role of both the psychosocial and biological influences on the development of social cognition in children with maternal prenatal SUD. Importantly, problems in early mother–infant interaction and maternal prenatal addiction severity, rather than SUD alone, were associated with difficulties in a child's emotion recognition and mentalization at school age. Furthermore, the mother–infant interaction quality also mediated the effect of maternal SUD on the child's emotion recognition.

Contrary to our hypothesis and previous findings among children prenatally exposed to nicotine and alcohol (e.g., Greenbaum et al., 2009; Reidy et al., 2013), mothers' prenatal SUD per se was not associated with the child's emotion recognition or mentalization. This may be at least partially because all the SUD mothers in our study received early integrated interventions, targeting both addiction and the mother–child relationship – which is the type of treatment usually described as the most effective (Moreland & McRae-Clark, 2018; Neger & Prinz, 2015). Indeed, a previous 10-year longitudinal study similarly failed to find any harmful effects of maternal addiction per se on children's mental health when mothers had attended substance use treatment (Hser et al., 2014). However, it should also be noted that the lack of behavioural differences does not rule out neural differences in social cognition. For example, Taylor, Eisenberger, Saxbe, Lehman, and Lieberman (2006) and Dannlowski et al. (2012) found that adults from high-risk families (including substance use) recognized angry and fearful faces much like controls did but showed deviant neurological responses (dampened or over-responsive amygdala response) to viewing the stimuli.

Interestingly, the mother's addiction severity rather than her SUD was predictive of the child's social cognition, but different aspects showed opposing effects. Higher *maternal prenatal alcohol dependence* predicted a child's poorer recognition of low-intensity emotions, that is, emotions that are harder to identify from subtle cues. Similarly, *mothers' perception of harm from drug use* predicted poorer recognition of high-intensity emotions and poorer emotion-specific recognition in all areas, including anger, sadness, fear and happiness. High dependence may be especially harmful: addiction has been associated with abnormalities in maternal brain functioning that are crucial for sensitive parenting (Landi et al., 2011; Rutherford & Mayes, 2017), thus potentially hindering maternal capacity to respond to and label the child's emotions. The perceptions of harm from drugs may reflect the struggle between the identities of a drug user and a mother and might be linked to deep feelings of guilt, helplessness and low parenting self-confidence, which may be harmful for adequate parenting and child development.

Curiously, and against our hypothesis, higher *maternal prenatal alcohol consumption* was associated with a child's better recognition of anger and low-intensity emotions. Similarly, higher *psychological drug dependence* was associated with better recognition of high-intensity emotions. Although the explanation is unclear, it is possible that these features represent higher adversity in the caregiving environment, leading children of severely alcohol- or drug-dependent mothers to highly tune their emotional perceptions into detecting subtle social cues (see Pollak &

Sinha, 2002). Heightened anger recognition, here linked with the mothers' higher alcohol consumption, is commonly found in maltreated children (Pollak & Sinha, 2002). Hypervigilant processing of emotions, especially anger, may help anticipate and cope with unpredictable caregiving behaviours in the context of heavy maternal substance use.

Higher addiction severity has also been linked with other mechanisms that may form a risk for parenting and child socioemotional development, including substance relapses (Simoneau & Brochu, 2017), maternal traumatic experiences (Gerra et al., 2014) and psychopathology (Gossop et al., 2001). It is possible that these factors, along with prenatal addiction severity, could indicate dangerous or dysregulating caregiving environments, leading to hypervigilant emotion processing. Along these lines, Lopez-Duran et al. (2013) found hypervigilant sadness processing in children with maternal depression. Interestingly, maternal prenatal addiction severity did not predict child mentalization, suggesting that prenatal addiction severity may be more relevant for early-developing basic capacities of emotion recognition (see Leppänen, 2011) than a more developmentally complex, higher order capacity for mentalization that develops later at the preschool age (Ensink & Mayes, 2010).

Our results especially highlighted the role of the first-year mother–infant interaction quality on children's social cognition. As hypothesized, after controlling for maternal SUD, high early mother–infant interaction quality predicted better social cognition at school age. Interestingly, the prediction seemed to be true concerning developmentally more complex aspects of social cognition, namely, recognition of low-intensity facial expressions, sadness and self-directed mentalization. These results on the beneficial role of early mother–infant interaction on child social cognition also extend previous findings from the children of normative and depressed mothers (Steele et al., 2008; Székely et al., 2014) to samples of children with maternal SUD. When children do not receive emotionally available parental interaction, where their emotions are mirrored and validated, they face difficulties in learning about their own and other people's emotions. At the same time, in a frightening or dysregulating parenting context, the child may especially learn to block out painful emotions, such as sadness, from conscious awareness (Dykas & Cassidy, 2011; Fonagy et al., 2012), and they may especially struggle with learning self-mentalization (Fonagy et al., 2012).

Furthermore, in line with similar findings on the cascading developmental pathways of maternal SUD via mother–infant interaction on other aspects of socioemotional development (e.g., Eiden et al., 2014), in our study, early mother–infant interaction quality mediated the effect of maternal SUD on the recognition of sadness and low-intensity emotions, as hypothesized. There was no mediation effect on mentalization, possibly suggesting that early predictors have less of an effect on this social cognitive capacity, which tends to develop later. It may also be the case that the effects of SUD on mentalization are age specific. Previous studies have shown that the harmful effects of prenatal nicotine and alcohol exposure on mentalization are the most evident in 4- to 8-year-old children (Reidy et al., 2013; Siklos, 2008), whereas the majority of children in our study were older.

The strengths of the present study include following a difficult-to-reach high-risk group over a long interval and using observational and experimental methods that are more reliable than self-reported data. The study, however, also has several limitations. Because of the small sample size, the results should be considered preliminary. Although data were missing at random and sophisticated methods of replacing missing data were used, the drop-out rate was high, especially in the SUD group. This may be because of the extremely challenging nature of keeping this population in long-term follow-up studies because of the instability in their lives, which here manifested as lacking a permanent address or rapidly changing contact information and having recurring difficult life circumstances, such as psychiatric hospitalizations or deaths and other trauma in their lives that may have hindered participation or contact.

Further limitations include that our measure of maternal substance use was based on self-report instead of health care records and drug-testing in urine samples and meconium. Substance-using mothers are generally considered overly optimistic in their self-reporting (Hennigan, Keefe, Noether, Rinahart, & Russell, 2006), so it is possible that self-reports underestimate the level of substance use. Furthermore, it cannot be ruled out that mothers with better mentalization or treatment motivation may be more honest in their self-reports. However, the low amount of newborn withdrawal symptoms in our study and concurring reports from clinicians about most mothers remaining abstinent during the intervention may somewhat support the maternal self-reports. More reliable documentation on the exact timing and amount of exposure would have been ideal. Also, our choice of a comparison group can be criticized because it consisted of children with medical rather than psychosocial risks. Yet this also made the groups medically and developmentally more comparable.

Further, including a measurement point between infancy and school age, for example, at preschool age, would have provided richer developmental information. It is important to note that SUD is a severe lifetime illness with recurrent relapses, always requiring long-term rehabilitation and support. In our sample, a high percentage of mothers still reported problematic substance use when children were at school age, and 60% reported intravenous use between childbirth and T4. The high rate occurred despite these mothers receiving intensive early interventions and potentially having less chaotic lifestyles that enabled them to participate in the study. We lack information on the full history of the mothers' substance use between T3 and T4, as well as the possible additional interventions they received during that period. Further, our results may not be applicable to children with high exposure levels throughout pregnancy because, in our sample, exposure was presumably most often restricted to early pregnancy. Similarly, results may differ for non-treated substance-using mothers, and even in our sample, there was some variation in the mothers' early treatment because three mothers had already started the intervention during the second trimester, while most had started just before childbirth. Starting treatment early in pregnancy may be more effective in situations of severe parenting risk (see Glover & Capron, 2017).

Future studies should also more carefully map the exposure effects on the functional and structural brain changes that underlie problems in social cognition. Also, neural, in addition to behavioural measures of social cognition in SUD children, should be examined because adult research suggests that some differences may only be evident at the latent biological level (Dannlowski et al., 2012; Taylor et al., 2006). Further, studies should also more carefully control for coexisting psychosocial risks for social cognition, for example, by using a high-risk control group or an adoptive sample in children with maternal SUD. Two important candidates for such mechanisms, which were outside the scope of the current paper, would be maternal mental health and traumatic experiences. Addiction severity, which was also found to be important for the children's social cognition in our study, has been linked with both of these (Gerra et al., 2014; Gossop et al., 2001). Research on these variables could potentially help explain our findings on the opposing roles of the different aspects of maternal addiction severity on child social cognition. Finally, the present study mainly concentrated on the effects of mothers' prenatal substance use, although it would also be important to follow how later substance use affects the development of children's social cognition. Multiple measurement points with the exact mapping of maternal use during the child's lifetime would be warranted.

4.1 | Clinical implications

Overall, our preliminary results suggest that maternal prenatal diagnosis of SUD alone may not—at least in samples receiving intensive early interventions—necessarily show long-term associations with a child's social cognition. Instead, the mother's addiction severity, as well as problematic early mother–infant interaction quality, may facilitate the recognition of children and families in need of long-term support. Our findings indicate that not all children with maternal prenatal SUD are equally at risk, which may ease the stigmatization of these families.

Our findings highlight the great importance of supporting all SUD mothers during the perinatal period. Deficits in social cognition have also been consistently reported among SUD mothers (Castellano et al., 2015; Sanvicente-Vieira et al., 2017), which may affect their ability to mirror, label and validate their children's emotions, representing an intergenerational transmission pattern of problematic social cognition. Interventions directly enhancing maternal social cognition, that is, mentalization-based interventions, have been shown to be effective for mothers with SUD (for a review, see Camoirano, 2017). Integrated substance use and parenting interventions have been robustly associated with the best treatment outcome (Moreland & McRae-Clark, 2018; Neger & Prinz, 2015), and including the infant in the treatment is known to promote the mother's treatment motivation and treatment outcome (Parolin & Simonelli, 2016).

An earlier Scandinavian study (Sandtorv, Haugland, & Elgen, 2017) showed that 92% of children who were referred to University Hospital with developmental impairment and were substance exposed, needed continuing support when they reached school age. It is crucial that a multidisciplinary team, including, for example, a psychiatrist specializing in psychoactive substances and a child mental health professional, together plan for long-term support for families with severe maternal addiction and mother–child interaction problems. The children would also benefit from interventions targeting mentalization and other social cognitive skills. There are new promising methods for children when it comes to focusing on learning ways to recognize and regulate emotions (e.g., Ornaghi, Brockmeier, & Grazzani, 2014; Sanchez, Lavigne, Romero, & Elosegui, 2019). Children living in high-risk conditions also need reliable adults who are available to share their burdens. Therefore, peer groups conducted by teachers and other supportive adults may be an integral part of enhancing their emotional development, though knowledge on the specific effectiveness of such school interventions is still very limited (for a review, see Schlesier, Roden, & Moschner, 2019). Future studies should identify the specific factors underlying parental mentalization and how to influence children's social cognitive skills during the different stages of development.

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CONFLICT OF INTEREST STATEMENT

The authors report no conflict of interest.

ETHIC APPROVAL STATEMENT AND PARTICIPANT CONSENT

The study was approved by ethical committee of Tampere University Hospital in all data collection phases (T1-T4) and at T1-T3 also by the committees of the participating clinics. The study has been conducted according to the ethical standards by Declaration of Helsinki.

All participating mothers and children provided informed consent. They were aware that participation was voluntary and they could cancel it any time, without providing reason.

We are not reproducing material from other sources.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ORCID

Marjo Susanna Flykt https://orcid.org/0000-0003-0874-4357
Jallu Lindblom https://orcid.org/0000-0003-4636-1226
Raija-Leena Punamäki https://orcid.org/0000-0003-4385-3073

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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