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Self-Recognition and Emotional Knowledge

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Abstract

Self-recognition emerges during the second year of life and represents the emergence of a reflective self, a metacognition which underlies self-conscious emotions such as embarrassment and shame, perspective taking, and emotional knowledge of others. In a longitudinal study of 171 children, two major questions were explored from an extant database: 1) Do early factors, including IQ, general environmental risk, mother-child attachment interaction, drug exposure, gender, and neonatal risk, relate to self-recognition?; 2) Does self-recognition, along with these earlier factors, predict the child's subsequent emotional knowledge? Consistent with previous data, 39% of children exhibited self-recognition by 18-months and few early factors explored were related to this ability. Moreover, path analysis revealed few effects of the earlier factors predicting self-recognition on children's emotional knowledge. Self-recognition did predict emotional knowledge at 4.5 years, such that children who showed early self-recognition showed greater emotional knowledge. Children from high risk environments also showed lower emotional knowledge. These findings indicate that self-recognition and environmental risk are related to children's later knowledge of emotions.

Keywords

Cognitive Development; Emotion Recognition; Facial Expression; Typical Development; Self-concept

Emotional knowledge (EK) has been defined as the ability to monitor one's own mental state as well as the mental state and emotions of others (Salovey & Mayer, 1990). Historically, it was also defined as social cognition or knowledge which includes knowledge of the self, knowledge of others, and knowledge of the possible relationships between self and other (Asch, 1952; Lewis & Brooks-Gunn, 1979; Shatz & Gelman, 1973). These definitions suggest that knowledge of the self may be an important step leading to the development of emotional knowledge in general. This study is interested in exploring in young children the relation between early self-knowledge, as measured by self-recognition, and later emotional knowledge. The present study addresses two questions related to individual differences in

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self-recognition in mirrors: first, the question of what factors may impact on the emergence of self-recognition; and second, the emergence of self-recognition related to subsequent emotional knowledge, and are the factors which are related to self-recognition also related to later emotional knowledge? To explore this problem, an extant longitudinal data base is used.

The relation of self-recognition to self-knowledge.

Self-recognition in mirrors has been used as a measure of self-knowledge along with measures of personal pronoun usage ("me" or "mine") and complex pretend behavior. It has been thought of as the first step of mentalism from which a theory of mind (TOM), or the ability to take the perspective of others, is derived (Leslie, 1987; Lewis, 2014; Lewis & Brooks-Gunn, 1979; Piaget, 1960).

If indeed the emergence of self-recognition as self-knowledge is related to emotional knowledge, it would establish a developmental framework by which knowledge of the self is considered central to the knowledge of others' emotional states, as well as to knowledge of the relationship between the self and other.

One means of measuring self-knowledge is through the mirror self-recognition task (Lewis & Brooks-Gunn, 1979). In this procedure, a rouge spot is placed on the child's nose surreptitiously and the child is asked to look in a mirror. Self-recognition is determined if the child looking in the mirror used their image to touch their nose. In addition to mirror recognition, children's personal pronoun usage, such as "me" and "mine," as well as complex pretend play, has been found to be related to their mirror recognition (see Lewis & Brooks-Gunn, 1979; Lewis & Ramsay, 2004). Children exhibit self-recognition beginning at 15 months of age, with almost all typically developing children showing mirror self-recognition by 24 months (Butterworth, 1992; Carmody & Lewis, 2012; Courage et al., 2004; Damon & Hart, 1988; Dawson & McKissick, 1984; Lewis, 2014). No gender differences have been found in self-recognition (Bertenthal & Fischer, 1978).

Factors influencing self-recognition are important to consider because they may have an indirect effect on EK through their direct effect on self-recognition. One such factor proposed to affect self-recognition is children's mother-infant attachment and their reactions to their mothers. There is the belief that the attachment relationship affects both children's self-knowledge as well as their emotional life (Bowlby, 1969). There are, however, few studies that directly test this idea. Lewis et al. (1985) and Tajima (1982) found support for *insecure* attachment as being related to self-recognition. They argue that stressful interactions between mother and child may result in the child spending more time alone, which may facilitate the development of self-other differentiation. Schneider-Rosen and Cicchetti (1991) also examined attachment as a predictor of self-recognition and showed that insecure attachment is related to early self-recognition. There is some evidence that culture-specific parenting behaviors, such as parenting style, may influence the onset of self-recognition (Keller et al., 2004), however there are few studies on this topic, and it is not clear that this relationship affects self-recognition or EK (Courage et al., 2004).

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Given that an extant database will be used, the variables so far discussed as affecting self-recognition can be examined. Also, because the database has data on the use of teratogens used by their mothers during pregnancy, namely cocaine, the effect of these on children's development also can be looked at. The Hobel Neonatal Risk scale was obtained, since teratogens may cause problems downstream, which in turn impact both IQ and emotional knowledge, and may affect self-recognition (Bendersky et al., 1996; Bennett et al., 2002, 2008).

Much of the evidence suggesting that IQ is related to self-recognition comes from studies with atypically developing children, such as those with autism and Down's Syndrome, who may be intellectually delayed and who also show self-recognition later than typically developing children (Carmody & Lewis, 2012; Lewis & Carmody, 2008; Mans et al., 1978; Reddy et al., 2010). Because of this, we predict that self-recognition and IQ will be related to EK, we also expect self-recognition and IQ to be related to each other (Cutting & Dunn, 1999; Greig & Howe, 2001; Pons et al., 2003). For example, Bertenthal and Fischer (1978), Brooks-Gunn and Lewis (1984) and Lewis and Brooks-Gunn (1979) showed that self-recognition is related to object permanence.

There is evidence that infant temperament may be related to self-recognition. Children who exhibit difficult temperaments — are slow to warm up and are difficult to soothe — show greater likelihood of showing earlier self-recognition (DiBiase & Lewis, 1997; Eggum-Wilkens et al., 2015). In the DiBiase and Lewis (1997) study, difficult temperament children, defined above, show earlier self-recognition. While these results seem counterintuitive, it may be that difficult temperament involves poor gating of pain; that is, part of a difficult temperament may be a low pain threshold – thus, more sensitive to their bodily activity. This in turn may increase their self-other differentiation and attention on themselves.

Examining Emotional Knowledge.

There have been many studies looking at young children's EK; see, for example, Michalson and Lewis (1985), Widen (2016), and Denham and her colleagues (2002) who have developed an EK protocol called the Affect Knowledge Test (Watanabe et al., 2019). The term EK captures a wide set of skills and varies with age (Pons & Harris, 2019). There are several different measures that appear in common to many studies, and include pointing to different facial expressions of emotions, naming of different facial expressions, and the child's knowledge of facial expressions in different situations (see Michalson & Lewis, 1985; Watanabe et al., 2019). In past work, Lewis and colleagues have examined EK in abused children using the 3 aspects as described (Bennett et al., in press; Michalson & Lewis, 1985; Sullivan et al., 2008; Sullivan et al., 2010) and which are found in the extant database. Similar measures were used by Harris et al. (2016) and Widen (2016).

Self-recognition and emotional knowledge.

There is considerable evidence to indicate that self-recognition is related to both concurrent as well as subsequent social and emotional knowledge. Darwin (1872) was one of the first to suggest that embarrassment occurs only once a child is aware that they are the focus of another's attention. To explore this further, Lewis et al. (1989) were able to demonstrate

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this assertion, showing that children exhibit embarrassment only after the emergence of self-recognition in mirrors. Self-recognition was unrelated to the earlier emerging emotions such as fear or joy.

Self-recognition has been related to subsequent emotional and social behavior. Sharing of toys occurs only after the emergence of self-recognition (Brownell et al., 2009, 2013; Kagan, 1981). Moreover, self-recognition has been shown to be related to empathy. Empathy, defined as knowledge about the emotions of others during distress emerges only after self-recognition in mirrors has occurred (Bischof-Kohler, 1988, 1991, 2012; Izard et al., 2001; Kokkinos & Kipritsi, 2012; Mayer et al., 1990).

Although the central thesis studied here is that self-knowledge is related to emotional knowledge, it does not preclude other factors which affect EK. Since both general intelligence and EK involve information processing, it is not surprising that studies have shown a relation between the two (Cutting & Dunn, 1999; Greig & Howe, 2001; Pons et al., 2003). Even so, Bennett et al. (2005) examined the differences between young children who were or were not abused by their parents and found that even when IQ was controlled, there were still group differences in EK; abused children showing lower EK than the non-abused group.

General environmental risk appears to affect children's acquisition of EK (Cutting & Dunn, 1999; Denham et al., 2012; Garner & Waajid, 2008; Gerard & Buehler, 2004). Environmental risk may affect children's EK directly or may affect it indirectly by impacting on IQ (Bryan et al., 2004). For example, prenatal cocaine exposure (PCE) and Hobel Neonatal Risk, a measure of perinatal health, are related to general environmental risk and IQ in children growing up in poverty homes (Bennett et al., 2002, 2008). Because environmental risk and IQ are related to EK, it is likely that prenatal cocaine exposure and Hobel Neonatal Risk, either alone or together, will affect children's emotional knowledge (Bendersky et al., 1996).

Children's EK can be affected through the mother-child relationship, which constitutes an important aspect of early socialization (Bennett et al., 2005; Bowlby, 1982). For example, children who are securely attached to their mothers are more likely to experience warm affect and emotional language from their mothers, facilitating social competence and EK (Bornstein et al., 1996; Denham & Kochanoff, 2002; Raikes & Thompson, 2006; Stefanović-Stanojević et al., 2015). Environmental risk can negatively affect the development of EK (Diener et al., 2003). Parental abuse is related to the recognition of negative emotions, such as anger and sadness, but hinders the recognition and expression of positive emotions (Garner, et al., 1994; Pears & Moses, 2003; Repetti et al., 2002). For these reasons it is hypothesized that self-knowledge as evidence by self-recognition is central to children's emotional knowledge, however, other factors such as IQ, environmental risk, and mother–child attachment should also be related.

Given the central hypothesis, that self-recognition is related to EK, availability of the variables of IQ, environmental risk, mother-child relationship, gender, prenatal cocaine exposure, and the Hobel Neonatal Risk scales, a measure of perinatal health found in the

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database and of some theoretical interest, can be used to explore the hypothesis that these additional variables, among others, directly affect EK or indirectly affect EK through the mediation of self-recognition.

Method

Participants

A sample of 171 children and their mothers were examined from an extant longitudinal data set which was gathered to determine the effects of fetal cocaine exposure on children's social, emotional, and cognitive development. Pregnant mothers were approached in hospitals in Trenton, NJ, and the Medical College of Pennsylvania in Philadelphia. Informed consent was obtained during this time. Children were excluded from the study if they had: a gestational age under 32 weeks, required special care or oxygen therapy for a period of time exceeding 24 hours, were prenatally exposed to phencyclidine (PCP) or opiates, exhibited congenital anomalies, had mothers under the age of 15, or had mothers that tested positive for HIV. Participants were predominately African American (81%), Caucasian (14%), and Hispanic (5%). Mother's median education level was 11^{th} grade (SD = 1.48 years), and 71% of the families received financial assistance. Participation was voluntary but mothers received incentives in the form of vouchers for use at local stores. Males comprised 48% (n = 83) of our sample.

Informed consent was obtained from all mothers prenatally and at each lab visit under Rutgers Robert Wood Johnson Medical School (formerly University of Medicine and Dentistry of New Jersey) IRB Protocol #021996X0702.

Procedure

Mothers were questioned at birth, and mothers and infants were first seen when the infants were 4 months old. Children were then followed several times a year until they were 17 years old. Cocaine exposure was gathered during pregnancy via a semi-structured interview (Bendersky et al., 1996). Prenatal cocaine use was confirmed by analysis of meconium and urine samples. Samples were screened with a radioimmunoassay followed by confirmatory gas chromatography-mass spectrometry for the presence of benzoylecgonine (cocaine metabolite).

Children of low-income mothers are at higher risk of pregnancy and delivery complications. To account for these complications, the Hobel Neonatal Risk Scale was obtained at birth from hospital records (Hobel et al., 1973, 1979; Sullivan et al.,, 2012).

The children and their mothers' data relevant to the focus of this study are presented in Table 1 and include the measures of interest obtained in a laboratory visit and the ages when they were administered.

Cocaine exposure and Hobel tests were obtained soon after birth. Variables that comprise the Hobel Neonatal Risk score include general health factors, such as 5-minute APGAR score, birth weight, fetal anomalies, respiratory complications, metabolic disorders, cardiac and hematologic problems, and central nervous system issues (see Table 1). The Hobel

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Neonatal Risk Scale generates an overall neonatal risk score reflecting the child's perinatal history; the higher the score, the more problematic the history. Child-mother interaction was obtained when the children were 12 months (± 1 month) of age (see Table 1).

Mother-Child Interaction.—Two measures of the environment were obtained. The first was the relation between the 1-year-old and its mother using the Ainsworth patterns of attachment — secure/approach and resistant/avoidant — scales during a reunion episode (Ainsworth et al., 1978). The reunion episode followed a 2-minute separation period which had followed a 5-minute free play period. The secure/approach scale measured proximity seeking behavior between mother and child. This scale rated positive distal social behaviors such as smiling, vocalizing, intent looking, showing of a toy, or playing through gestures, as well as proximal behaviors such as climbing, creeping, crawling, or walking toward the mother. The resistant/avoidant scale measured resistant behavior between mother and child during free play and reunion. This scale rated negative facial expressions made by the child as well as proximal behaviors such as protesting, lack of smiling, and ignoring mother's vocalizations. A composite attachment score was obtained for each child by reversing the resistant/avoidant scale.

Environmental Risk.—The second environment scale considered was a measure of general environmental risk. A cumulative Environmental Risk score was derived for each child (Bendersky & Lewis, 1998). This score included: 1) maternal life stress, as measured by the Social Environment Inventory (Orr et al., 1992); 2) maternal social support based on the Norbeck Social Support Questionnaire (Norbeck et al., 1981); 3) the number of regular child caregivers (with higher numbers indicating greater risk); 4) the irregularity of the child's schedule and the instability of the child's surroundings as measured by the Family Chaos Scale; 5) single parenthood (whether a single caregiver lived alone with the child); 6) maternal ethnicity; 7) maternal education; and 8) public assistance or work status. Composite environmental risk scores such as this have been used previously and possess greater predictive power than single factor scores (Atzaba-Poria et al., 2004; Bendersky & Lewis, 1994, 1998; Bennett et al., 2015; Deater-Deckard et al., 1998; Sameroff et al., 1993).

Mirror Self-Recognition at 18 months.—Children were scored as either showing mirror self-recognition or not. Children and their mothers were escorted into a playroom by a research assistant and given some time to warm up prior to the self-recognition task. After a few minutes, mothers surreptitiously placed a spot of unscented, dark red rouge on their children's nose. Once application of the rouge was complete, the research assistant engaged in brief play with the child in order to ensure that the child's behavior during the task was not due to tactile stimulation experienced during the application process. The research assistant then led the children to the one-way mirror and tapped it while saying, "look here, look here". At no point did the researcher refer to the children's nose, name, or reflection. The researcher stood to one side of the mirror throughout this process so that their reflection was not visible in the mirror. This process was repeated until the children looked at the mirror on four successive occasions for at least 5 seconds or until the children touched their noses. The nose touching was scored as yes or no.

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Each child's mother was present throughout the process but was instructed to remain silent. Examination of video recordings from each session indicated that none of the children received maternal prompting. Self-recognition was evaluated on the basis of whether the child touched their nose while looking at the mirror (Lewis & Brooks-Gunn, 1979, Lewis & Ramsay, 2004; Loveland, 1986; Mitchell, 1993). Interobserver agreement was 100%.

IQ.—Children were administered the Bayley Scales of Infant Development-II (Bayley, 1993) at 30 months. A standardized Mental Developmental Index (MDI) was computed for each child. Previous work examining children from this at-risk, low SES group showed that children exhibit below average IQ (Bennett et al., 2002).

Emotional Knowledge (EK).—While several measures of EK were available, we used a previously developed EK measure used with a similar sample of children (Bennett et al., in press; Sullivan et al, 2008, 2010; Watanabe et al., 2019). The measure utilized 3 scores which generated an overall measure of EK and included children's production of emotional words, comprehension of emotional words, and emotional script knowledge. These 3 tasks were obtained together when the children were between 4 and 5 years old and a total score derived from them.

Production of emotional words.: Children were shown six photographs of a young girl ("Felicia") making different facial expressions and were asked to produce an emotional label for each expression (i.e., happiness, sadness, anger, fear, surprise, or disgust). The experimenter asked children: "what kind of face is Felicia making?" or "how does Felicia feel?". Responses were scored correct if children produced the correct emotional word. Appropriate synonyms, such as "angry" for the mad face or "yucky" for the disgust face, were accepted as correct. The order of emotions was random. While the faces of a young girl were used, the gender of the faces makes no difference in the results (Sullivan et al., 2010). This task has been used by others (Garner, 1999; Garner et al., 1994; Izard et al., 2000, 2001; Michalson & Lewis 1985; Miller et al., 2005; Watanabe et al., 2019; Widen & Russell, 2003, 2008).

Comprehension of emotional words.: Comprehension of emotional words was assessed using the same stimuli described during the production of emotional words task. Stimuli were randomly placed on a table so that children could see all six emotional expressions at once. The experimenter instructed children to point to a specific face when prompted: "point to the happy face" or "how does Felicia look when she is happy". After children completed all six expressions, the cards were reshuffled and the task was repeated. The order in which children were asked about specific emotions was random in both instances of the task. Comprehension scores were coded correct if the child pointed to the corresponding expression on both trials. This task has been used by others (Garner, 1999; Garner & Waajid, 2012; Michalson & Lewis, 1985; Watanabe et al., 2019; Widen & Russell, 2008).

Emotional Script knowledge.: The ability to match facial expressions to context was assessed by presenting 10 brief vignettes, each of which focused on one of the six emotions used during production and comprehension tasks. Each vignette was illustrated by a line drawing in which the character's facial expression was not shown. For example, children

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were told “Felicia does not like broccoli but her mom asks her to eat broccoli anyway. How does Felicia feel?”. Children were then prompted to point to one of the six pictures of Felicia. After a choice was made, the experimenter said, “Good. Did Felicia make any other faces?”. If children said “yes”, the experimenter prompted them to point to a second face. Correct responses were counted if the child pointed to the target face with either choice. Vignettes were presented in a random order. This task has been used by others (Garner, 1999; Garner et al., 1994; Garner & Waajid, 2012; Michalson & Lewis, 1985; Watanabe et al, 2019; Widen & Russell, 2003, 2008).

Because the scores for these tasks were highly correlated ($r = .80$s, $p < .01$) a summary score for these 3 tasks was used for the measure of EK. Power analysis using the G*power calculator indicated that this longitudinal sample was sufficient to detect medium to large effect sizes. All procedures and materials were approved by the Institutional Review Board at the University of Medicine and Dentistry of NJ (now Rutgers Robert Wood Johnson Medical School).

Results

Little’s Missing Completely at Random (MCAR) test was used to examine whether or not any missing data exhibited regular patterns. Results indicated that the data missing were random, $\chi^2(27) = 29.00$, $p = 0.36$, therefore, we imputed the missing values using a Markov Chain Monte Carlo (MCMC) algorithm of multiple imputation over 100 iterations. This procedure has been shown to provide accurate statistical estimates of missing data based on the available data (Schafer & Graham, 2002).

The results are presented around the 2 major questions proposed: (1) what are the biological and social factors which may be related to the onset of self-referential behavior as measured by self-recognition?; and (2) what is the relationship between self-recognition and children’s EK, as well as the relationship of other factors besides self-recognition? Here we were interested in examining the direct relationship between the two using correlational analyses, path analyses, and examining the unique variance attributed to each variable through regression analysis.

Factors Influencing Self-Recognition

Because the children in this sample were from poverty homes, a comparison of their behavior to children from middle-class homes was undertaken. Comparable scores were available for self-recognition and each of the three tasks that comprised EK for middle class children. The proportion of children who exhibited self-recognition at 18 months in this sample is 39%, which is consistent with the rates of 29%, 33%, and 47% found in 18-month-old middle class children by Schneider-Rosen and Cicchetti (1991), Lewis and Brooks-Gunn (1979), and Lewis and Ramsay (2004). While poverty does not appear to influence mirror self-recognition, EK, on the other hand, was lower in this sample than in middle class children. For the production of emotional words, the mean percentage correct in the current sample was 29%, while in the Widen and Russell (2003, 2008) studies it was 58% and 63%, and in the Garner (1999) study it was 72%. The current subjects scored lower

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on emotional script knowledge than middle class children, with a mean score of 38% vs. 67% in the Garner (1999) study.

Table 2 shows the intercorrelation between all the variables under study: EK, self-recognition, IQ, mother-infant attachment interactions, general environmental risk, Hobel Neonatal Risk, cocaine exposure, and gender.

None of the early variables were correlated with self-recognition except IQ, and indicated that earlier self-recognition is related to greater IQ. Showing self-recognition was also positively correlated with EK, while EK itself was positively correlated IQ, negatively correlated with ER, and higher for girls than boys. While more resistant/avoidant interaction was not related, either to self-recognition or EK, it ws related to the Hobel Neonatal Risk score. This suggests that poor maternal interaction is related to difficult and risky perinatal status. This is consistent with the reported relation between EK, IQ, and environment.

In order to examine any developmental path between the early variables of cocaine exposure, Hobel Neonatal Risk, gender, environmental risk at 4 months, mother-infant interaction at 12 months, mirror recognition at 18 months, and IQ at 30 months, a fully specified path model was used to predict EK. This model examined the direct effects of all variables on EK, as well as possible indirect effects mediated by self-recognition. The model yielded a comparative fit index [CFI] = 1.00 and a root mean square error of approximation [RMSEA] = 0.00.

The only variable to have a significant direct effect on self-recognition was IQ, ($\beta = .29$, $p = .02$, 95% CI [.05, .52]). In terms of EK, self-recognition, ($\beta = .19$, $p = .02$, 95% CI [.02, .32]) and IQ, ($\beta = .22$, $p < .01$, 95% CI [.08, .37]) had significant direct effects. This was also true for environmental risk, ($\beta = -.22$, $p < .01$, 95% CI [−.36, −.08]). These findings demonstrate that while direct effects were found for EK, there were no indirect mediation effects of any early variables whose paths went through self-recognition.

Hierarchical Linear Regression

Because no mediation effects were found in the path analysis, hierarchical linear regression was used to predict EK from all other variables and to assign unique contribution to the major variables under study. Several interaction terms were explored, however, given the sample size, the number of these interactions had to be limited. These interactions consisted of self-recognition in interaction with ER and mother-infant interaction given our continued interest in determining the effect of self-recognition (perhaps a biological variable) with the 2 environmental variables. We were also interested in whether sex differences and IQ would affect the findings given that the girls had higher scores on EK.

In order to examine the unique contribution of self-recognition on EK while also examining possible interactions between self-recognition with environmental risk, self-recognition with mother-infant attachment interaction, and gender with IQ, we conducted a hierarchical linear regression as seen in Table 3. All assumptions for hierarchical regression were met due to collinearity statistics, normality, and homoscedasticity being within acceptable ranges. Self-recognition was entered into the regression at level 1 since it addressed the main

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question of the study, while mother-infant interaction, IQ, environmental risk, neonatal risk, cocaine exposure, and gender were entered into the regression at level 2. Lastly, the interaction terms between self-recognition and environmental risk, self-recognition and mother-infant interaction, and gender and IQ were added to the model at level 3. These interaction terms were selected based on the results of the Sullivan et al. studies (2008, 2010). As Table 3 indicates, there was no significant change in model fit between levels 2 and 3, therefore level 2 was used as the final model. The model accounted for 19% of the variance in EK. Self-recognition predicted EK, even when controlling for all other variables, indicating that self-recognition uniquely contributed to the prediction of EK. IQ also uniquely predicted EK, indicating that children with higher IQs generally exhibit better EK. Lastly, environmental risk predicted EK, with children growing up in less risky environments exhibiting higher EK scores. The interactions between self-recognition and environmental risk, and self-recognition and mother-infant interaction, did not uniquely contribute to emotional knowledge.

Discussion

The findings reported here that self-knowledge is related to EK support the concept of EK "as the ability to monitor one's own and others' feelings and emotions, to discriminate among them — one's own and others' — and to use this information to guide one's thinking and actions" (Salovey & Mayer, 1990, p. 189). It also speaks to Shatz and Gelman's (1973) earlier concept of social cognition which stresses the idea that these cognitions involve knowledge of both self and other. That self-knowledge, as measured by mirror self-recognition, is related to subsequent emotional knowledge, independent of other variables, allows us to begin to construct a theory on the development of EK. By using self-recognition as a measure of self-knowledge, it has been possible to relate it to other aspects of emotional life; for example, Bischof-Kohler's (1988, 1991, 2012) findings that self-recognition is associated with empathy, where empathy was defined as knowledge of the emotions of others and the showing of appropriate behavior in the presence of other's distress, or Lewis et al's. (1989) demonstration that the emergence of self-recognition and embarrassment are related. In addition, self-recognition is related to the emergence of the personal pronouns of "me" and "mine," and to self-directed pretend play (Lewis & Ramsay, 2004). These findings suggest that mirror recognition captures at least some aspects of self-knowledge.

Lewis (2014) suggested a parallel between self-knowledge and EK and that the development of each level of self-knowledge is related to EK. For example, the first level involves "I know," which refers to observations that infants are capable from birth of understanding contingent relationships (Gergely & Watson, 1996; Watson, 1966). The second level, "I know that I know," constitutes the emergence of mentalism and the onset of self-recognition. It is similar to a memory of a memory. The third level, which may be part of the second, is "I know you know." This involves the subject's start of perspective taking understanding (see Leslie, 1987). The fourth level involves recursive knowledge, "I know you know I know." It is in this fourth level where social relationships can be said to begin. This developmental progression reflects Salovey & Mayer's (1990) idea that emotional knowledge involves the ability to monitor one's own mental state as well as the mental state and emotions of others.

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Emotional knowledge in 4–5 year olds was measured by examining a set of skills that we and others have used: children's comprehension of words associated with emotional expression; the production of emotional terms; and the knowledge of scripts — showing knowledge of what facial expressions are likely to occur in particular social situations (Denham et al., 2002; Garner, 1999; Garner et al., 1994; Izard et al., 2000, 2001; Michalson & Lewis 1985; Miller et al., 2005; Pons & Harris, 2019; Widen & Russell, 2003, 2008). Children from a poverty background show significantly worse EK than middle class children, likely because of language differences by social background. Poverty children are spoken to less and are less likely to be spoken to about emotions (Alaimo et al., 2001; Camras & Allison, 1985; Denham, 1998; Pons et al., 2004; Sameroff, 1998). The participants in this study were part of a longitudinal study on the effects of general environmental risk and fetal cocaine exposure. In this study, as well as in those mentioned above, the effect of poverty on language development as well as IQ differences and attentional abilities has been noted in children from poverty environments (Carmody et al., 2011). There is also evidence that parenting language use affects emotional development (Alessandri & Lewis, 1993). General environmental risk appears to be related to EK.

Of interest, however, was that these poverty children's self-recognition ability did not differ from middle class children. It has been suggested that self-recognition is related, in part, to brain maturation such that earlier maturation of the left temporal-parietal region as well as the medial frontal cortex are related to its emergence (Frith, 2001; Lewis & Carmody, 2008; Samson, et al., 2004; Saxe et al., 2004; Saxe & Kanwisher, 2003). Thus, brain maturation as related to self-recognition does not appear to be affected by poverty, although the subsequent development of EK does. Clearly, more study is needed in order to determine the effects of poverty on both brain maturational processes as well as on culturally derived knowledge and the interaction between them.

The interest in the relationship between self-recognition and subsequent EK affords the opportunity to examine a developmental sequence which could describe this process. We examined early factors such as cocaine exposure, neonatal risk as measured by the Hobel Neonatal Scale, general environmental risk score, and mother-infant attachment status as they affected self-recognition, which in turn was predicted to be related to EK. A path analysis was performed which examined this possibility. Although the model was significant, there was no significant indirect path from these earlier variables that was mediated through self-recognition to EK. These results suggest that self-recognition independently exerts an effect on EK and that general environmental risk independently also affects it.

What then might be related to self-recognition? This was explored by examining environmental risk, mother-child attachment, cocaine exposure, neonatal risk, and IQ. Self-recognition was not related to the mother-child relationship nor environmental risk. Studies observing the relationship between attachment and self-recognition give mixed results (Lewis et al. 1985; Schneider-Rosen & Cicchetti, 1991; Tajima, 1982). These findings, as well as our finding that mother-infant attachment did not influence self-recognition, suggest that the role of attachment on self-recognition remains an open question. In any event, attachment is likely to affect the content of self-knowledge, rather than its onset.

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Lewis (2014) has proposed that, like object permanence as suggested by Piaget (1962), the emergence of self-knowledge or awareness might be related to maturational processes, while the content of self-knowledge may be culturally determined. In support of the social influence on self-recognition is Keller et al.'s (2004) observation that the social structure of the culture influences self-recognition, although more work on this problem is necessary.

Self-recognition, like emotional knowledge, was related to IQ. Emotional knowledge was also related to a gender difference, with girls showing higher emotional knowledge scores than boys, a finding reported by others (Naghavi & Redzuan, 2011; Petrides & Furnham, 2000). Clearly, when measuring knowledge of either self or others, IQ is likely to play a role. That self-recognition, independent of IQ, still demonstrates an association with emotional knowledge suggests that IQ becomes more important as a control variable. For example, in the Bennett et al. (2005) study IQ was accounted for when examining environmental risk and emotional knowledge, but as that study pointed out, most studies do not examine IQ when investigating emotional knowledge (Cook et al., 1994; Izard et al., 2000).

This large sample of children from a poverty background provides an opportunity to examine and confirm the central thesis of this study, that self-recognition as a measure of self-knowledge is related to EK. Clearly, this sample shows poorer performance on measures of EK than the more typical studies using middle class children. There is no reason to believe, however, that the developmental pathway provided here should be different as a function of poverty compared to the developmental pathway provided by studying middle class children. Even so, more work with a middle class sample is needed to ensure the generalization of these results.

Conclusion

In the second year of life, children come to recognize themselves in mirrors (Lewis & Brooks-Gunn, 1979; Lewis & Ramsay, 2004). This ability is also highly related to the child's use of personal pronouns such as "me" or "mine", and is also related to complex pretend play. These behaviors represent the metacognition or representation of "me", and are necessary for the development of social behaviors such as empathy and sharing, and for emotions like shame.

This early metacognition is also related to knowledge of others' minds and therefore to the onset of knowledge of others' emotions. The present study supports the idea that the onset of this metacognition, as is self-recognition, is perhaps related more to brain maturation than to environmental factors such as poverty. Given that children on the autism spectrum have developmental difficulty in self-recognition and subsequent social and emotional problems, early diagnosis using mirror recognition may prove useful for the creation of early interventions that may aid them in the development of these skills.

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The data that support the findings of this study are available from the corresponding author, Michael Lewis, upon reasonable request.

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Table 1

Extant Measures by Age of Child *

Time	Measure
Birth	Cocaine Exposure
	Hobel Neonatal Risk Scale
12 months	Mother-Child Interaction Attachment Measure
18 months	Mirror Self-Recognition
30 months	IQ test
4 – 5 years	Emotional Knowledge Measures
	Environmental Risk Score

* These measures were obtained in a laboratory setting as well as data collected from hospital records. It took over 2 years to register the sample, starting in February 1993.

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Table 2

Zero-order correlations between Emotional Knowledge, Self-Recognition, IQ, Mother-Infant Interaction, Environmental Risk, Hobel Neonatal Risk, Cocaine Exposure, and Gender

	1	2	3	4	5	6	7	8
1. Emotional Knowledge	-							
2. Self-Recognition	.20**	-						
3. IQ	.32**	.23**	-					
4. Mother-Infant Interaction	.11	.09	.08	-				
5. Environmental Risk	−.22**	−.05	−.11	.05	-			
6. Hobel Neonatal Risk	.09	−.12	−.02	.42**	.11	-		
7. Cocaine Exposure	.11	.07	.01	.11	.14	.18*	-	
8. Gender (Girls = 1; Boys = 2)	−.15*	−.15	−.24**	−.05	−.01	.07	−.01	-

* $p < .05$.

** $p < .01$.

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Table 3

Summary of the Hierarchical Regression Analysis by Model Predicting Emotional Knowledge

	Model 1		Model 2		Model 3	
	β	**95% CI**	***β***	**95% CI**	***β***	**95% CI**
Self-Recognition (SR)	.20**	.11, .72	.14*	.01, .59	.14*	.01, .59
IQ			.25**	.10, .39	.22*	.01, .43
Mother-Infant Interaction			.03	−.13, .19	.08	−.10, .26
Environmental Risk			−.22**	−.36, −.08	−.21*	−.38, −.04
Hobel Neonatal Risk			.10	−.05, .26	.10	−.06, .26
Cocaine Exposure			.12	−.05, .54	.12	−.05, .55
Gender (Girls = 1; Boys = 2)			−.08	−.45, .13	−.08	−.46, .12
SR x Environmental Risk					.01	−.31, .32
SR x Mother-Infant Interaction					−.09	−.51, .14
Gender x IQ					.04	−.24, .35
R^2	.04**		.19**		.20**	
F for change in R^2	7.26**		5.16**		0.50	

*$p < .05$.

**$p < .01$.