

Growth in Emotion Understanding across Early Childhood: A Cohort-Sequential Model  
of Firstborn Children across the Transition to Siblinghood

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## Growth in Emotion Understanding across Early Childhood: A Cohort-Sequential Model of Firstborn Children across the Transition to Siblinghood

### Abstract

Emotion understanding develops rapidly in early childhood. Firstborn children ( $N = 231$ , 55% girls/45% boys, 86% White, 5% Black, 3% Asian, 4% Latinx,  $M_{\text{age}} = 29.92$  months) were recruited into a longitudinal study from 2004 to 2008 in the U.S. and administered a series of tasks assessing eight components of young children's emotion understanding from ages 1 to 5. Cohort sequential analysis across three cohorts (1-, 2-, and 3-year-olds) demonstrated a progression of children's emotion understanding from basic emotion identification to an understanding of false-belief emotions, even after controlling for children's verbal ability. Emotion understanding scores were related to children's theory of mind and parent reports of empathy, but not emotional reactivity, providing evidence

of both convergent and discriminant validity.

Keywords: emotion understanding, early childhood, cohort sequential analysis, transition to siblinghood

## **Growth in Emotion Understanding across Early Childhood: A Cohort-Sequential Model of Firstborn Children across the Transition to Siblinghood**

Emotion understanding (EU) refers to the ability to “understand the nature, causes, and consequences of the emotional experience” (Pons & Harris, 2019, p. 432). EU develops rapidly in early childhood and allows children to become sophisticated connoisseurs of emotional experience (Brown & Dunn, 1996; Pons & Harris, 2019). Children’s EU is related to fewer internalizing and externalizing behavior problems (Trentacosta & Fine, 2010), better sibling relationships (Volling et al., 2002), and higher social competence with peers (Klein et al., 2018). Thus, understanding the developmental progression of children’s EU across the early years will provide further insights into children’s social and emotional competence.

Children acquire multiple EU skills along a developmental timeframe, mastering more basic EU skills such as emotion identification before obtaining more advanced EU skills, such as understanding mixed emotions. Yet, most studies on children’s EU are cross-sectional and only assess a limited number of EU skills at one age (Castro et al., 2016) rather than addressing the growth of EU over early childhood. This limitation is no doubt due to the time needed to conduct longitudinal studies to track EU over time, but also to the lack of a clear understanding of the progression of EU skills over the critical years of early childhood. One exception is the cross-sectional study of Pons and colleagues (2004) in which 100 children in the UK between ages 3 to 11 were administered the Test of Emotion (TEC) that assessed nine EU components. They found age differences suggesting that children developed EU in an ordered progression starting with emotion recognition and advancing to an understanding of moral emotions. Denham (1986) also developed a series of tasks to assess four components of EU (e.g., emotion identification) in a sample of 27 2- to 3-year-olds in the U.S., finding that children as young as 2 started to understand basic EU components. The primary goal of the current

investigation was to examine the development of EU in very young children starting already at 1 year of age, and through cohort-sequential modeling, examine growth in EU until age 5. We took advantage of a unique longitudinal design that utilized different age cohorts of firstborn children that had been administered a series of EU tasks at three times across the year following the birth of an infant sibling. This cohort-sequential design provided a robust examination of the progression of EU in early childhood and actual growth in EU over a period of approximately one year, in contrast to cross-sectional studies examining age differences.

### **Components of EU across Early Childhood**

Prior research has identified several key components of EU in early childhood, such as emotion identification, emotion labeling, and understanding mixed emotions (Pons & Harris, 2019). The current study adapted methods from extant EU assessments to select eight EU components (Denham, 1986; Gordis et al., 1989; Jones et al., 1998; Vinden, 1999; Wellman & Woolley, 1990) that we believed best described the progression of EU across early childhood, with the ultimate goal of creating an ordinal scale of EU, in which children needed to master one EU skill before advancing to the next. These tasks were then administered to firstborn children as part of a longitudinal investigation examining children's adjustment after the birth of an infant sibling, also known as the transition to siblinghood. EU was targeted because children's EU was related to more cooperative and friendly sibling relationships in prior research (e.g., Brown & Dunn, 1996; Youngblade & Dunn, 1995), suggesting that children's EU might predict the firstborn's acceptance of their infant sibling. Because firstborn children varied considerably in age (10 to 67 months) when the sibling was born, a single age-based assessment of EU would not adequately assess the full range of EU skills, whereas a battery of tasks capturing growth in EU might. Because such a battery did not exist for 1- to 5-year-olds at the time the study was designed, the first and primary aim of this exploratory investigation was to compose a battery of EU tasks to assess very young children's EU and to determine the ordinal sequence of the EU components.

### **The Developmental Progression of Children's EU in Early Childhood**

The most basic understanding of emotion is the ability to identify (point to a facial expression when given an emotion label; Component I) and label facial expressions

(verbally label a facial expression; Component II) of happiness, sadness, anger, and fear (Denham, 1986). We focused on these four basic emotions because children start to understand these emotions at an early age before secondary or self-conscious emotions (see Widen, 2013 for a review) and because they have been used most frequently in other EU assessments. With the development of language and emotion knowledge, 2- to 3-year-olds in a U.S. sample started to identify and label emotions (Denham, 1986), and more than 50% of 3-year-olds from lower to middle-class families in the UK were able to identify and label these emotions (Pons et al., 2004). Although some have theorized that children start identifying facial expressions as early as 1 to 2 years of age (Pons & Harris, 2019), no study has actually assessed 1-year-olds by asking them to point to or label emotions. In the current study, firstborns ranged in age from 10 to 67 months at the first measurement before the birth of their sibling, and were administered the same tasks again at two additional time points, when their infant sibling was 4 and 12 months, allowing us to assess EU in children of varying ages and track growth in EU longitudinally.

Starting between 2 to 3 years, children can make accurate emotion inferences in stereotypical situations (Component III; Denham, 1986) where most people would feel the same emotion. For example, when children are told a person is alone in the dark, they can infer that this person will feel scared. In a sample of children from lower to middle-class families in the UK, 30% of the 20 three-year-olds and 65% of the 20 five-year-olds made correct inferences about emotions in stereotypical situations (Pons et al., 2004). More than 80% of the 60 five-year-old Chinese children made correct inferences about emotions in stereotypical situations (Tang et al., 2018).

Also, around 2 to 3 years, children begin to understand desire-based emotions (Component IV; Wellman & Woolley, 1990). From a functional perspective, whether an individual achieves a goal or not is a core source of emotional experiences (Barrett & Campos, 1987). For instance, sadness is experienced when one feels the goal is unattainable, and happiness is felt when the goal is achieved. When asked to make correct emotion judgments based on whether desires are met or not, 13 out of 16 two-year-olds in a predominantly White, middle-class US sample made correct judgments, understanding that getting what one wanted made one happy and failure to achieve one's desires made one sad (Wellman & Woolley, 1990).

As children mature and become more sophisticated in their EU, they begin to make correct emotion inferences in non-stereotypical situations (Component V; Denham, 1986) around 4 years of age (Pons & Harris, 2019). Here, children begin to understand that others may experience a different emotion from their own in a given situation. For example, children understand that other people may feel scared when encountering a large dog, even though they themselves may feel happy in the same situation. At around 42 months, children in a predominately White US sample passed half of the emotion inferences in non-stereotypical situations tasks (Eggum et al., 2011). Similarly, 4- to 6-year-olds in a primarily European American sample were able to correctly answer 80% of the non-stereotypical emotion inferences tasks (Dunsmore & Karn, 2004).

Between the ages of 4 and 6, children start to make correct inferences about emotions based on false beliefs (Component VI; Vinden, 1999), in which children develop an understanding that people's emotions are based on their beliefs about a situation even when those beliefs are mistaken. For example, someone who needs crayons would feel happy to find a crayon box without knowing the box is empty. About half of the 75 primarily European American 3- to 5-year-olds made accurate judgments of emotions based on a mistaken belief (Wellman & Liu, 2004). When administered false-belief and emotion prediction tasks together, 6-year-olds from Australia, North America, and Europe performed significantly above chance on the false belief and emotion prediction questions, whereas the 4- and 5-year-olds did not (Vinden, 1999). Discrepancies in findings may be due to the variation in the difficulty of the tasks across studies or cultural variations in when this EU component is mastered by children. For instance, Vinden (1999) found that children from Mofu did not pass these false belief and emotion prediction tasks above chance until 7 or 8 years of age.

Beginning at age 5, children start to understand emotion display rules (Component VII; Jones et al., 1998) that guide socially appropriate displays of emotion that may differ from their internal feelings. Children must learn rules about expressing emotions to meet social expectations and demands (Zeman & Garber, 1996) so when given an undesirable gift, for instance, 5-year-old children may feel huge disappointment, but know that the socially appropriate reactions to the receipt of a gift are to express one's happiness and then extend a gracious "thank you" to show appreciation. Jones et al.

(1998), in a sample of 121 primarily White middle-class US children, showed that third graders scored significantly higher in all the display rules tasks than did kindergarteners.

One of the more advanced means of understanding emotions is the ability to understand mixed emotions (Component VIII; Gordis et al., 1989). Three-year-olds believe that people can only experience one emotion in any given situation, but starting around 5 to 6 years of age, children begin to understand that people may experience multiple emotions at the same time (Brown & Dunn, 1996; Pons et al., 2004). In a sample of 105 racially diverse US children, 56% of the 5- to 6-year-olds reported the character in a story had sequential mixed emotions, but only 3% reported the character had simultaneously mixed emotions. For older ages, 36% of the 8- to 9-year-olds and 63% of the 11- to 12-year-olds reported simultaneously mixed emotions (Larsen et al., 2007).

Using firstborn children from 10 to 67 months old when first assessed, the current study focused on the growth in EU across early childhood based on tasks chosen and adapted from prior studies to assess each of these eight EU components. Based on the research just reviewed, we hypothesized that EU would progress in an ordered sequence, starting with emotion identification (I) and emotion labeling (II), then emotion inferences in stereotypical emotion situations (III), desire-based emotions (IV), emotion inferences in non-stereotypical situations (V), emotions based on false beliefs (VI), emotion display rules (VII), and ending with mixed emotions (VIII). Once we were successful in determining age differences in children's performance on the EU tasks and had a potential ordering, our next task was to create an individual EU score for each child based on the number of components each child passed to be used in cohort-sequential modeling.

It should be noted that most research on young children's EU has been derived from studies of predominantly Western, educated samples of White middle-class children, and it remains to be determined whether any sequence of EU is culturally universal. In research examining the ordinal sequence of children's theory of mind (ToM) understanding, 3- to 5- year-old Chinese children acquired ToM understanding in a different sequence from U.S. and Australian children (Wellman et al., 2006) and we suspect the same may be true for children's EU. Thus, the current research should be viewed only as a preliminary exploration of one possible developmental sequence of EU for very young children in a sample of predominantly White U.S. children undergoing the

transition to siblinghood. Any sequence uncovered here will require further investigation with children from different sociocultural backgrounds.

### **Understanding Children's EU Using Cohort-Sequential Modeling**

The second goal was to examine growth in EU using cohort sequential modeling (Nesselroade & Baltes, 1979), which produces a developmental function that reveals whether there is a consistent pattern of growth across age. Cohort sequential modeling divides participants into independent age cohorts and then links adjacent segments of short-term longitudinal change from these different age cohorts to approximate a longer term developmental curve (see Prinzie & Onghena, 2005 for a more detailed description). To do so, we selected firstborn children between 1 to 3 years whose EU was assessed at the first measurement point (T1) before the infant sibling's birth, and then divided them into three age cohorts (1, 2, and 3 years). Children were then administered the same battery of EU tasks when their infant siblings were 4 (T2) and 12 months (T3) of age as part of the longitudinal investigation. These three scores were used in cohort-sequential modeling to create a developmental trajectory of EU. Because children's verbal ability is directly associated with performance on EU tasks (e.g. Denham et al., 1994; Gal-Szabo et al., 2019), we controlled for children's verbal ability in our cohort-sequential modeling.

### **Testing the Convergent and Discriminant Validity of the EU Scaling**

As a final goal, we examined both the convergent and discriminant validity of children's EU scores with other indicators of children's social cognition and emotional functioning. Children's social cognition includes understanding beliefs and emotions (Cutting & Dunn, 1999), and children develop a more advanced understanding of both EU and ToM with age, which may account for the robust association found between EU and ToM (e.g. Cutting & Dunn, 1999; O'Brien et al., 2011). Thus, we used a validated measure of ToM (Wellman & Liu, 2004) to investigate the associations between EU scores and ToM as a test of convergent validity. Given prior research showing that EU predicts individual differences in children's empathy (Ensor & Hughes, 2005), which is the ability to feel and understand another's emotional state, we also expected children's EU scores to be associated with parents' reports of empathy, as another means of demonstrating convergent validity. Finally, we examined associations between children's EU scores and negative emotional reactivity (i.e. anger/frustration) to examine divergent



validity of our EU scores. The reactive component of temperament, which refers to the biologically rooted individual differences in children's emotional reactions (Rothbart & Derryberry, 1981), was chosen because children's EU scores should reflect their cognitive understanding of emotions and not necessarily emotional reactivity, which has been the case in previous studies showing no relation between emotional reactivity, especially anger, and EU (Klein et al., 2018; Verron & Teglassi, 2018).

### **The Current Study**

The current investigation examined the development of EU in very young children starting at 1 year of age using data from a longitudinal study designed to follow firstborn children from before to one year after the birth of an infant sibling. The sample in this case consisted of two-parent, mother-father families in the U.S., the majority of which were middle-class and European American. The longitudinal design and a wide age range of children from 1 to 5 years allowed a robust examination of a developmental growth trajectory of EU in early childhood using cohort-sequential modeling. The research reported is exploratory by design because no prior study has attempted to order EU components with children this young. There were three specific aims to the current study: (1) to determine the ordinal sequence for an EU scale for young children; (2) to confirm the developmental progression and trajectory of EU over early childhood using cohort sequential modeling; and finally, (3) to demonstrate the convergent and discriminant validity of children's EU scores. We will refer to the resulting ordinal scale from these analyses as the Emotion Understanding in Early Childhood (EUEC) scale.

### **Methods**

#### **Participants**

Participants were firstborn children from a longitudinal study of changes in the family after the birth of a second child conducted with two-parent mother-father families in the Midwestern U.S. (see Volling, Gonzalez et al., 2017). We refer to the firstborns as children throughout the remainder of this paper. Participants included 241 families recruited from 2004 to 2008 through advertisements, local obstetric clinics, childbirth classes and hospitals with the initial prenatal contact occurring during the last trimester of the mother's second pregnancy and subsequent time points at 1, 4, 8, and 12 months after the infant's birth. A recruitment sample size of 240 was chosen to allow for 15% attrition

and a final sample of 200 at 12 months which would allow adequate power (.80) for conducting multilevel modeling with moderate effect sizes (Snijders & Bosker, 2012). The study was approved by the Institutional Review Board of the University of Michigan Medical School. At the prenatal time point, children were, on average, 29.92 months old,  $SD = 10.16$  (range = 10 - 67 months). Mothers, 85.9%, and fathers, 86.3%, were primarily European American/White, followed by African American/Black, 5.4% mothers and 5.0% fathers, Asian American, 2.9% mothers and 3.7% fathers, Hispanic, 3.7% mothers and 2.9% fathers, and Other, 2.1% mothers and 1.7 % fathers. Most parents, 83.9% mothers and 79.2% fathers, had a bachelor's degree or higher, and the median annual family income was \$60,000 - \$99,999. Of the 241 families recruited, 217 and 203 families remained in the study at 4 and 12 months, respectively, the two latter time points at which the EUEC was administered. The 203 families remaining at 12 months did not differ significantly from the families that dropped from the study on years of marriage, parents' age and race/ethnicity, children's age and gender, and children's EUEC scores at the initial pre-birth assessment (T1). Families who remained had higher annual family incomes, *Fisher's exact* = 10.75,  $p = .01$ ; and both mothers,  $\chi^2(2, N = 241) = 7.90$ ,  $p = .02$ , and fathers, *Fisher's exact* = 9.37,  $p = .02$ , had higher educations than those who dropped.

### **Research Design and Procedures**

EUEC assessments were conducted with children at three times: prenatal (T1), and when infant siblings were 4 (T2), and 12 months (T3). At T1, 228 children completed the EUEC assessments; 214 and 196 children were assessed at T2 and T3, respectively. Missing data were due mainly to the inability to schedule a visit within the time frame (+/- 2 weeks) for each point of data collection or because families had moved. Six children at T1, 3 at T2, and 1 at T3 had missing data because children were too young to understand the task, did not assent to participate, or refused to continue participation during the assessment. Thus, a total of 231 children had completed the EUEC assessment at least once across the three time points and were maintained in the analyses.

For present purposes, we relied on existing EU tasks that had documented reliability and validity for specific age groups (see online supplemental materials). All tasks focused on the four basic emotions (happy, sad, scared, and angry) because they are

the most commonly used emotion responses in previously developed tasks. Further, children understand these four basic emotion categories at an early age before secondary or self-conscious emotions such as guilt, pride, or embarrassment that older children may understand (Widen, 2013). This choice also meant that the emotion response options were the same across all eight EUEC components and we were not introducing additional confounds when assessing EU.

- EUEC assessments were administered by a trained research assistant during home visits conducted at T1, T2, and T3, usually in the child's bedroom, which was quiet and free of distractions, while parents were completing an interview administered by a second research assistant in another part of the home. All tasks were administered in the same order to all children based on the hypothesized sequence. Although children's performance on emotion identification (Component I) is significantly better than for emotion labeling (Component II; Markham & Adams, 1992), we administered labeling before identification so as not to expose children to the emotion labels during the identification tasks beforehand and then increase performance on the labeling tasks; a practice consistent with that of others (e.g. Denham, 1986).

Given the very young age of some of the children, a stop rule had to be established as younger children were less likely to understand the more advanced EU components and unlikely to finish the entire series without inducing fatigue, stress, and resistance that could affect performance. The stop rule was applied when a child completed none or only one task in a component across two consecutive components. Similar stop rules have been used in other age-based assessments such as the Wechsler Preschool and Primary Scale of Intelligence - Third Edition (WPPSI-III; Wechsler, 2002) and the Peabody Picture Vocabulary Test – Third Edition (Dunn & Dunn, 1997).

## Measures

**Emotion understanding in early childhood (EUEC).** EU was assessed using tasks adapted from prior studies and ordered a priori based on extant research at the time the study started in 2004. For each EUEC component, there were 3 to 4 tasks, with each task including 1 to 4 questions, which allowed children multiple attempts to demonstrate their understanding rather than relying on only one task per component. When 3 tasks were used to assess an EU component, children needed to correctly complete at least 2

out of 3 (66%) to pass, and when 4 tasks were used, they need to correctly complete 3 out of 4 (75%). Each child was then given a passing score (1 = pass, 0 = fail) for each of the eight components. When the stop rule was imposed children were given a score of 0 for the remaining higher ordered components. An EUEC score was computed at each of the three time points for each child to reflect the number of components each child was able to pass. The EUEC tasks can be found in the online supplemental materials.

■ **Emotion labeling (Component II).** To assess children's ability to label emotions, we used tasks from Denham (1986) in which children were asked to verbally label four basic facial expressions of happiness, sadness, anger, and fear. Experimenters introduced a puppet that was the same sex as the child and placed four faces with happy, sad, angry, and scared expressions of emotion in random order in front of the child. Experimenters then pointed to each face and asked, "how does s/he feel when s/he wears this face?" Experimenters rearranged the faces for each of the four trials. Children passed the component if they labeled at least 3 out of 4 emotion faces correctly. Labeling was administered before identification to prevent children's prior exposure to the emotion labels when asked to identify an emotional expression.

**Emotion identification (Component I).** We also used the emotion identification task from Denham (1986) in which children were asked to identify the four facial expressions of happiness, sadness, anger, and fear by pointing to the correct facial expression of each emotion when asked (e.g., "Show me a face where s/he feels happy/sad/mad/scared"). Experimenters rearranged the faces for each of the four trials. Children passed the component when correctly identifying 3 of the 4 emotion faces.

**Emotion inferences in stereotypical emotion situations (Component III).** Four tasks from Denham (1986) were also used to assess children's understanding of emotions in situations where most people would feel the same emotion (e.g., happy when given ice cream). Experimenters used a puppet to enact four vignettes using obvious facial and emotional cues, and children were asked to find the face that showed the puppet's feeling in the situation and affix it to the face of the puppet. Four faces with happy, sad, angry, and scared expressions were rearranged in front of children for each vignette. Children passed this component if they chose the emotion faces correctly at least 3 of the 4 times.

**Desire-based emotions (Component IV).** The three desire-based emotion tasks,

taken from Wellman & Woolley (1990), assessed children's understanding of emotions based on whether people's desires were met. Children were introduced to cardboard cut-outs of three characters with no facial expressions and were shown three sets of pictures depicting two locations (e.g., green or red barn; see online supplemental materials). Children were told three stories in which the characters really wanted to find the desired object (e.g., Betsy really wants to find her horse to take her horse to the pond. Her horse might be in the red or the green barn). Then the characters looked for the object in one of the locations (e.g. Betsy is looking for her horse in the green barn. She does not find her horse). Children were shown a happy and a sad face and were asked "Does she/he feel happy or does she feel sad?" Children answered correctly if they answered happy when the character found what they desired and sad when they did not, and passed this component if they answered at least 2 of the 3 tasks correctly.

**Emotion inferences in non-stereotypical situations (Component V).** Four tasks from Denham (1986) measured children's understanding of emotional reactions in a particular situation, but the emotion was the opposite of what the children themselves would feel in that situation. Beforehand, mothers completed a sheet describing four different situations (e.g. is your child happy or scared to see a big dog?) and circled the emotion they believed their children would most likely express. Experimenters then used a same-sex puppet to enact, using obvious facial and emotional cues, the four situations but expressing emotions opposite from what mothers identified as their children's most likely emotional reaction. Four faces with happy, sad, angry, and scared expressions were rearranged in front of children for each vignette. Children were asked to find the face that showed how the puppet was feeling and put it on the puppet's face. Children passed the component if they identified at least 3 of the 4 emotions enacted by the puppet correctly.

**Emotions based on false beliefs (Component VI).** Three tasks, taken from Vinden (1999), measured children's ability to predict other people's emotions when their belief about the situation is mistaken (false belief). Children were given three scenarios depicting false beliefs where a picture character (e.g. Pam) was looking for crayons or Band-Aids. In each scenario, children were shown two boxes, a box in which the objects inside were the same as the image on the box (e.g. crayons in a crayon box) and an empty unmarked box (e.g. with no crayons). Experimenters then removed the desired objects

from one box and placed them in the other (e.g. putting crayons from the crayon box into the empty box). Experimenters pulled out a cardboard picture character and placed it in front of children and said “Pam is looking for her crayons, but did not see what we did”. Children were asked two questions to test false belief understanding: (a) where will the character (e.g., Pam) look for the desired objects (e.g., crayons), and (b) will the character find them? To test children’s ability to predict emotions based on false beliefs, children were asked two additional questions about how the character would feel, happy or sad, before and after the character looked for the desired objects. For example, “before Pam looks for the crayons, how will she feel, happy or sad?” and then once the box revealed no crayons “after Pam looks for the crayons, how will she feel, happy or sad?” Children successfully completed a task if they answered all four questions correctly. Children passed the component if they completed at least 2 of the 3 false belief tasks correctly.

**Emotion display rules (Component VII).** Three tasks measuring children’s capability to understand the socially appropriate rules for displaying emotions were taken from Jones et al (1998). Beforehand, experimenters trained children to use two sets of face cards to represent emotions, one set represented the character’s feelings on their face on the outside, and a second set of internal feeling cards showed the image of a child without facial features but with a facial expression drawn on its chest to represent internal feelings (see images in online supplemental materials). The outside face cards and internal feeling cards illustrated expressions of happy, sad, angry, and neutral. The character was gender-matched to children. Experimenters told children three stories (e.g. Jimmy/Nancy receiving an ugly sweater as a present from grandmother) and asked them to use an internal feeling card to match the character’s feeling on the inside (e.g., sad) and then a face card to match the character’s emotion display on the outside (e.g., happy). Children passed the emotion display rules component if they answered both the internal feeling and the emotion display on the outside correctly for at least 2 of the 3 tasks.

**Mixed emotions (Component VIII).** The three mixed emotions tasks from Gordis et al. (1989) assessed children’s understanding of the presence of two opposite-valenced emotions in one situation. Using characters the same sex as the children, children were told three stories in which the characters felt both positive and negative emotions, such as happy and sad, mad or scared (e.g., Jane/Jack felt both happy and sad about going to the

zoo without daddy who was sick). For each story, children were asked to explain why the characters felt both positive and negative emotions, and their responses were recorded. Children's explanation for each emotion was later coded by trained research assistants using 0 = the emotion was not explained or 1 = a plausible explanation provided for the emotion. For reliability, children's explanations for emotions were double-coded at the first time point, and the Kappa reliability ranged from .87 to .98. For each story, children needed to provide plausible explanations for both the positive and negative emotions to answer the task correctly. Children passed the mixed emotions component if they gave reasonable explanations for both emotions for at least 2 of the 3 tasks.

**Theory of Mind (ToM).** To assess convergent validity of EUEC scores, we also administered the 6 tasks from the ToM scale by Wellman & Liu (2004) at the same three time points, which included (a) a not-own desire task where children judged whether two persons could have different desires about the same object; (b) a not-own belief task where children judged whether two persons could have different beliefs about the same object when they did not know if the beliefs were true; (c) a knowledge access task where children saw the object in a box and judged whether another person, who did not know what was in the box, would know the contents of the box; (d) an explicit false-belief task where children judged where another person would look for an object based on a mistaken belief; (e) a contents false-belief task where children judged whether another person would have a true or false belief about an object in a distinctive container when children knew it was an unexpected object in that container; and (f) a real-apparent emotion task where children judged whether another person could feel one emotion but display another emotion instead (see detailed description of each task in Wellman & Liu, 2004). This standard test battery of ToM has been widely used across several different countries (Wellman et al., 2006). A composite score was created by summing children's pass/fail in each task at each of the three time points, so scores ranged from 0 to 6.

**Empathy.** Both mothers and fathers completed the 13-item empathy scale from the My Child questionnaire (Kochanska et al., 1994) at T1, T2, and T3 using a 7-point scale (1 = extremely untrue to 7 = extremely true; e.g., "child will try to comfort or reassure another in distress",  $\alpha = .77 - .82$ ). Items were averaged and a composite score was created by averaging across mothers and fathers scores,  $r = .42 - .67$ , all  $ps < .001$ , to

reduce single-reporter bias and to create a more robust composite.

**Temperament.** Mothers and fathers completed five scales of the Children's Behavior Questionnaire (Rothbart et al., 2001) at T1 to assess children's temperament, including anger/frustration (13 items, e.g., "Becomes easily frustrated when tired";  $\alpha = .73 - .77$ ) using a 7-point scale (1 = extremely untrue to 7 = extremely true). Items were averaged for the anger/frustration scale and composite scores were created by averaging scores across mother and father reports,  $r = .53$ ,  $p < .001$ . Children's temperament was measured only at T1 as part of the longitudinal investigation as a pre-birth predictor of children's adjustment after the sibling's birth. Individual differences in children's temperament are moderately to highly stable over a one-year-period (e.g., Casalin et al., 2012), which approximates the first year after the birth in the current study.

**Verbal ability.** The 38-item receptive vocabulary subtest of the Wechsler Preschool and Primary Scale of Intelligence - Third Edition (WPPSI-III; Wechsler, 2002) was used to assess children's verbal ability at T1, T2, and T3. A set of four pictures were placed in front of children, and experimenters then asked children to point to the one that experimenters named aloud (e.g., "Show me the foot."). Children were given 1 point if they pointed to the correct picture; otherwise, children received 0 points. Experimenters used a stop rule and stopped the test if children received five consecutive scores of 0. Total scores were summed across items.

### **Data Analysis Plan**

To address the first aim to develop a sequence of EU components from the most basic (passed by most children) to the most advanced (passed only by older children), we conducted two sets of analyses. First, we conducted frequency statistics by noting the number of children who passed each component, and then ordered the components based on how many children passed from the most to fewest children. Next, to examine whether older children passed more components than younger children, we divided children into seven one-year age groups at all three times ( $\leq 12$  months, 1 year (13-24 months), 2 years (25-36 months), 3 years (37-48 months), 4 years (49-60 months), 5 years (61-72 months), and 6 years (73-84 months)) and examined the mean number of components each group passed, expecting older groups to pass more components.

Once we settled on an ordered sequence from the descriptive analyses, we



computed an EUEC score for each child at each time and then used cohort-sequential modeling (Nesselroade & Baltes, 1979; Twenge et al., 2017) to create a single developmental trajectory of EU that models the growth in EU across the three times of measurement. In the cohort-sequential modeling, we restricted the sample to children whose ages were between 1 to 3 at T1 ( $N = 220$ ) because there were too few children outside this age range to be included in the modeling as an independent age cohort ( $n = 2$  for <1 year;  $n = 7$  for 4-year-olds; and  $n = 2$  for 5-year-olds). Children were then divided into three age cohorts: cohort 1 (one-year-olds) included children aged 13 to 24 months at T1 ( $n = 81$ ,  $M \text{ age} = 20.12$ ,  $SD = 2.76$ ); cohort 2 (two-year-olds) included children aged 25 to 36 months ( $n = 88$ ,  $M \text{ age} = 29.80$ ,  $SD = 3.42$ ); and cohort 3 (three-year-olds) included children aged 37 to 48 months ( $n = 51$ ,  $M \text{ age} = 40.75$ ,  $SD = 3.08$ ). The data from each cohort provided information for a portion of an overall developmental curve showing growth in EU (see Figure 1) from 14 to 62 months or 1 to 5 years. In the current investigation, cohort sequential models were estimated using linear mixed models (LMMs) with restricted maximum likelihood estimation using R 3.6.1. First, a baseline model was estimated to model an overall age-related trend in children's EU:

$$EU_{ti} = (\beta_{00} + u_{0i}) + \beta_{10} * Age + \beta_{20} * Cohort2 + \beta_{30} * Cohort3 + \varepsilon_{ti} \quad (1)$$

Age was centered at 20 months (the mean age in cohort 1) so that the intercept  $\beta_{00}$  represented children's estimated EU when they were 20 months old. A random effect  $u_{0i}$  represented individual variability in the intercept.  $\beta_{10}$  represented the linear slope coefficient for the overall age trend. Cohort was dummy coded, so  $\beta_{20}$  and  $\beta_{30}$  represented cohort effects for cohorts 2 and 3 and can be interpreted as cohort-specific intercept terms.  $\varepsilon_{ti}$  represented the error variance. To test whether the linear slopes were the same or not for each of the three cohorts, we estimated a second model in which the interaction between age and cohort was added to the baseline model. We then performed a third model, adding children's verbal ability to the second model, to test whether the age and cohort effects would remain the same after controlling for the main effect of children's verbal ability. Children's verbal ability was centered at 4.87 (the mean score in cohort 1). To address the third aim demonstrating the convergent and discriminant validity of our EUEC scale, we conducted correlations with children's ToM, empathy, and anger/frustration temperament, as well as partial correlations controlling for

children's age and verbal ability.

## Results

### Developmental Sequence of EU Components

To address the first aim, we rank ordered each EU component according to the actual number of children who passed each component. Table 1 shows the sequence of the components based on this ranking and the number of children passing each component across each of the three time points. The same developmental progression across the eight EU components was found at all three time points: (1) emotion identification, (2) desire-based emotions, (3) emotion labeling, (4) emotion inferences in stereotypical emotion situations, (5) emotion inferences in non-stereotypical situations, (6) emotion display rules, (7) mixed emotions, and (8) emotions based on false beliefs. This sequence is different from the initially hypothesized order and administration of the tasks based on a review of the literature. To confirm this sequence further, we examined whether older children were passing more components than younger children. As can be seen in Table 2, older children, on average, passed more components than younger children, indicating that EU increased with age consistent with the sequence found above.

[Table 1 goes here]

[Table 2 goes here]

### Developmental Growth in EU

To confirm the growth in children's EU followed a developmental function, we conducted cohort sequential analyses to approximate an overall developmental curve using the data from the 1-, 2-, and 3-year-old cohorts. A linear mixed model indicated that there was no significant child sex nor sex by time interaction predicting EU, so child sex was not included in further analyses. As shown in Figure 1, there was a steady growth in children's EU across early childhood. Results from Model 1 showed that children who were 20 months old, on average, did not pass any EU component,  $B = -.10$  (see Table 3), although children could, on average, complete .18 more EU components every month,  $B = .18$ , which is about two additional EU components every year, demonstrating an overall upward developmental trend in EU. The significant interaction between age and cohort in Model 2 (see Table 3) shows that the rate of increase in EU was different across the three cohorts. The slopes were not significantly different for cohorts 1 and 3,  $B = .00$ , 95% CI[-

.03, .04], but were significantly different for cohorts 1 and 2,  $B = .06$ , 95% CI[.03, .09], and cohorts 2 and 3,  $B = -.05$ , 95% CI[-.09, -.02], indicating that 2-year-olds had a slightly faster growth rate in EU compared to 1-year-olds and 3-year-olds. The results from Model 3 (see Table 3) demonstrated that higher verbal ability was significantly associated with higher EU, but even after controlling for verbal ability, the general developmental trend in EU did not change.

■ [Table 3 goes here]

[Figure 1 goes here]

Figure 1. Developmental trajectory of children's EU. Solid lines are drawn from observed data, and dashed lines are based on estimated data from the cohort sequential modeling. Child age in the figure was the median age for each cohort at the 3 measurement time points. For cohort 1, child age ranged from 14 to 24 months at T1; from 20 to 30 months at T2; and from 28 to 39 months at T3. Cohort 2 were children who were 25 to 36 months old at T1, 30 to 43 months old at T2, and 38 to 51 months old at T3. For cohort 3, children's age ranged from 37 to 47 months at T1, 42 to 53 months at T2, and 49 to 62 months at T3.

### **Convergent and Discriminant Validity**

To assess the convergent and discriminant validity of children's EUEC scores, we correlated each child's EUEC scores with ToM scores, and parents' reports of empathy and anger reactivity (temperament) within each time of measurement, while controlling for children's age and verbal ability. As shown in Table 4, EUEC and ToM were significantly correlated with each other and continued to be significantly related even after controlling for children's age and verbal ability, providing convergent validity for children's EUEC scores with another indicator of children's social cognition. Children's EUEC scores were also correlated with parents' reports of children's empathy at each time, although correlations between EUEC and empathy became non-significant once age and verbal ability were controlled. Finally, children's EU scores were not significantly correlated with children's temperamental anger reactivity, after controlling for age and verbal ability, demonstrating discriminant validity.

[Table 4 goes here]

### **Discussion**

The overarching goal of the current investigation was to advance research on children's EU by examining eight abilities that describe very young children's EU and then determine the developmental progression of EU across early childhood. Our results showed that within this sample of mostly White, middle-class US families with firstborn children undergoing the transition to siblinghood, there was indeed a developmental sequence to children's EU that unfolded with age. The order based on 231 children's responses to EUEC tasks at all three times was slightly different than the initial hypothesized sequence based on our review of the literature when the study was started. Emotion identification was passed by most children in our sample before emotion labeling, which surprisingly, was passed by fewer children than desire-based emotions. Desire-based emotions, which we anticipated would be more advanced beyond emotion identification and labeling was actually ranked as the second component in our data-based investigation. As expected, the remaining components followed a progression from emotion inferences in stereotypical emotion situations, emotion inferences in non-stereotypical emotion situations, emotion display rules, and mixed emotions. Unexpectedly, emotions based on false beliefs, which we administered as the sixth of the eight components, appeared to be the most advanced EU skill as it was only passed by a few of the oldest children in the sample. Further support for this developmental sequence was found by looking at how individual children progressed across the three time points, with more children passing each of the successive components as they got older. We proceed to discuss the sequence of EU uncovered here and attempt to explain what may account for the findings and why they may have differed from the original hypothesized ordering that determined the sequence administered to children.

### **Uncovering the Developmental Progression of EU in Early Childhood**

One of the strengths of this research was demonstrating how EU developed across a wide age range of children from 1 to 5 years using age cohorts of firstborn children from a longitudinal investigation examining the birth of an infant sibling. Further research is clearly needed to try and replicate these results to determine if the sequence uncovered here does indeed reflect young children's developing understanding of emotions across other diverse cultures and for families from different socioeconomic and racial/ethnic backgrounds. But, until that time, we discuss the findings as they reflect

children's EU for the current age cohorts of predominantly White, middle-class firstborn children from two-parent, mother-father families participating in a longitudinal study around the birth of the second child in the Midwestern U.S.

Children acquired emotion identification before an understanding of desire-based emotions, which preceded emotion labeling. This developmental sequence of EU was unexpected because previous research suggested identification and labeling were the most rudimentary EU skills that children begin to acquire around 1 to 2 years (Denham, 1986; Pons & Harris, 2019), whereas it is not until 2 to 3 years that children begin to understand the impact of desires on emotions (Wellman & Woolley, 1990). Emotion identification and labeling may at first glance look quite similar, but they required different abilities from children. Emotion identification required children to comprehend the emotion term (e.g., "show me the happy face") and then match that emotion by pointing to the correct facial expression, whereas emotion labeling required children to retrieve the information from the emotional expression, code the information into an emotion term, and verbalize the word. These abilities to identify and then label emotions are similar to receptive versus expressive language abilities in which comprehending language requires limited processing of the linguistic input but producing words requires coding information and providing linguistic output (Cromer & Ault, 1979). The ordering of the two EU components, emotion identification before labeling, was consistent with previous research suggesting that matching a basic emotion expression with a given emotion term was easier for young children than verbally labeling an emotion expression using emotion vocabulary (Harrigan, 1984; Markham & Adams, 1992).

Not surprisingly, children differentiated basic emotion expressions before they became aware that an individual's emotional state was dependent, in part, on whether their desires were met or not. What was surprising was to uncover that children understood desire-based emotions before they were able to label basic emotion expressions. In the desire-based emotions tasks, children were provided two emotion categories, happiness and sadness, to choose from; that is to say, children only needed to understand that fulfilled desires led to positive emotions, such as happiness, and unfulfilled desires resulted in negative emotions, such as sadness, to pass the tasks. In the emotion labeling tasks, however, children needed to produce at least three different emotion terms

that correctly matched the emotion expressions to pass the tasks, which might be more difficult for young children because children understand emotions as two broad positive or negative valence-based categories first and then gradually differentiate different discrete emotion categories (Widen, 2013). When provided with only two emotion options to choose from in the desire-based emotions tasks versus four options in the labeling tasks, children had a higher chance of picking the answers correctly in the desired-based emotions tasks. This difference in chance performance might account, in part, for the current order, so further research is needed to replicate these findings.

Once children mastered emotion labeling, children were then passing tasks that were other-focused such as understanding others' emotions based on situational cues and knowledge of what people would typically feel in those situations (stereotypical emotion situations) before they could infer a person's felt emotions in non-stereotypical situations in which the person's felt emotion was different from what the children themselves would feel in these same situations (see Denham, 1986). Making inferences about another's emotional state required children to differentiate self as distinct from others and to take the other person's perspective. Making a correct prediction about another's emotions when that emotion is the same as children's own emotion is easier than when the emotion is different from what children themselves may feel, because the former does not require children to suppress the self-perspective (Ruby & Decety, 2004).

The current results also revealed that children understood emotion display rules before mixed emotions. Though both EU components involved understanding two emotions, understanding emotion display rules required an understanding that an individual actually felt only one emotion, but chose to display a different emotion to others that matched cultural expectations of proper conduct, whereas understanding mixed emotions required that children grasp that a single event could result in two felt emotions simultaneously. To pass the emotion display rules tasks, not only did children need to understand the appearance-reality distinction and know the rules guiding appropriate displays of emotions in social contexts (Banerjee, 1997), but they also needed to use their affective perspective-taking skills to infer another's feelings in a given situation. In the current study, children were asked to verbally provide plausible explanations for the two emotions felt in the mixed emotions tasks instead of merely

naming the two emotions. Having to provide causal explanations for the two felt emotions added another level of difficulty to the mixed emotions tasks, which could be a reason for the resulting rank ordering.

Unexpectedly, an understanding of display rules and mixed emotions preceded a higher order understanding of false belief emotions, which we found to be the most advanced EU component with only the oldest children around 5 years of age passing it. To pass this component children needed to understand that a person's emotional experience can be based on a mistaken belief, so that what the person feels is not based on reality but what that person believes to be the case. To understand emotions based on false beliefs, children needed to incorporate the roles of both beliefs and desires when making emotion inferences. That is, children needed to demonstrate their understanding of false beliefs first and then to make two correct emotion inferences, once when a person held a false belief and once after the person found out the belief was false. Previous research, however, has used only one task that required children to make one correct inference based on a false belief (e.g. Pons et al., 2004), and thus found children passed this component before mixed emotions. It is clear the false belief emotions task used here required children to attend to the integration of belief-desire reasoning, which might be why emotions based on false beliefs was the most difficult EU component to pass.

### **Developmental Growth in EU Across Age Cohorts**

Similar to the work of others (Denham, 1986; Pons et al., 2004), we were able to demonstrate that there is a diverse set of EU components that can be ordered into a developmental sequence even at very young ages from 1 to 5 years. Using a sample of 3- to 11-year-olds, Pons and Harris (2004) developed a set of EU tasks and also found that EU advanced along a developmental progression starting with a recognition of basic emotion expressions and ending with an understanding of moral emotions in a cross-sectional study. Our EUEC assessment specifically targeted very young children and is the first investigation to use a cohort-sequential design using longitudinal data to examine the rate of growth in EU across these early years of childhood.

The cohort sequential analysis showed convincingly that children acquired around two additional EU components every year starting at age 2. Differences in the slopes across cohorts showed that 2-year-olds had slightly faster growth in EU compared to the

1- and 3-year-old cohorts. Children, on average, acquired the first EU component (emotion identification) around the beginning of age 2. Most children being unable to pass any EU component before the age of 2 may be the reason why the 1-year-olds had a slower increase in EU. Yet, EU appeared to develop rapidly in the year that followed. The booming growth in basic EU skills for the 2-year-olds is consistent with children's growing ability to speak about mental states and their development in social cognition around this age. For instance, children start to use mental state (e.g. emotion and cognition) words at around 20 months and their use of these words burgeons at around 28 months (Bretherton & Beeghly, 1982). Similarly, children start to comfort and tease others at age 1, but their repertoire of comforting and teaching behaviors expands around age 2 (Harris, 2007). Collectively, children's social cognition, including EU, appears to grow more rapidly starting at age 2. After a rapid acquisition of the basic EU skills from 2 to 3 years of age, children's rate of acquiring more advanced EU skills seemed to slow, which may suggest that children need time to master some of these more advanced EU skills, starting at 3 to 4 years of age. The higher task demands of the later EUEC tasks administered to older children in this study may have also contributed to our findings of slower growth in EU for the 3-year-old cohort.

### **Validity of the EUEC Assessment**

As hypothesized, children's EUEC scores were positively correlated with their ToM scores at all three time points, showing that children's EU and ToM, which theoretically should be correlated because they are both indicators of children's social cognition (Cutting & Dunn, 1999), were, in fact, related. Thus, the EUEC assessment demonstrated good convergent validity with an established and widely-used measure of ToM (Wellman & Liu, 2004). EUEC scores were also correlated with children's empathy, as reported by parents, although the correlations became non-significant after controlling for children's age and verbal ability.

We were further able to demonstrate the EUEC assessment's divergent validity with children's negative emotional reactivity. Children's EU ability should reflect their cognitive understanding of emotional experiences and not necessarily their biologically rooted emotional reactivity. The results that children's EUEC scores were not correlated with children's anger/frustration temperament provided evidence that the EUEC scores



did not reflect the reactive component of children's temperament.

### **Limitations and Future Directions**

Although this is the first study to demonstrate growth in EU for very young children using a cohort-sequential design, the findings must be interpreted in light of the limitations of this research. First, all children were firstborns participating in a study examining the transition to siblinghood. These children resided in two-parent, mother-father families in the U.S., the majority of which were middle-class, European American families. Even though the current sample enabled us to take advantage of the naturally occurring age cohorts of firstborns upon the birth of a sibling and then apply cohort sequential modeling to reveal a longer term developmental function, we must acknowledge that the current work was exploratory and must be replicated with children from different cultural and social backgrounds. Because family dynamics have an impact on children's EU (Halberstadt & Eaton, 2003) and the interactions with a newborn sibling create a natural context for children to learn about emotions (Dunn & Kendrick, 1982), the results may be limited in their generalizability to other cohorts of young children not undergoing the transition to siblinghood. Additionally, our findings may not reflect the development of EU in all cultures. Molina et al. (2014) found that more Italian preschoolers understood the differences between expressed and internal feelings than did German preschoolers. Work on the ToM scale has also suggested that children in collectivist societies, such as China, appeared to follow a different sequence of ToM than children in individualistic societies, such as the U.S., because different cultural values may direct children's attention to one mental state concept before others (Shahaeian et al., 2011). The same cultural differences may be true with the ordered development of EUEC scores uncovered here, so we encourage researchers to continue conducting research to replicate and extend knowledge on the development of EU for children from different cultures.

Second, this is the first study to examine longitudinal EU development in children less than 24 months of age using a battery of EUEC tasks. For this reason, a stop rule had to be applied during the administration of the tasks because young children were unable to complete the full series of tasks. This stop rule, however, may have affected the results found here, specifically some of the later tasks, because the order in which tasks were

initially administered meant that some of the more difficult tasks (false belief emotions) were administered before others we believed would emerge later (mixed emotions). In addition, because our choice of tasks was intended to correspond with children's increasing EU, the task demands for each component varied, with more advanced components requiring higher language and attention abilities, and thus, requiring more time to administer. However, four of the early EU components relied on tasks taken directly from the widely-used assessment of EU developed by Denham (1986), so this issue is clearly not unique to the work reported here. Nonetheless, we must acknowledge that the differing task demands across EU components may have influenced the sequence found in the current study.

Third, the EUEC scale was based on tasks with already demonstrated reliability and validity from previous studies, so we felt confident in including these tasks as part of a series to be used across a wider age range of children. However, there were also disadvantages of using existing tasks given that the number of tasks presented to children in each component differed, as well as the task demands and time needed to administer the tasks for each component. Given the different number of tasks administered, the questions asked, and the response options across the various components, the chance levels of passing components also differed. These differences may also have played a role in the observed developmental progression. Thus, our results need to be interpreted with caution until future research can replicate these findings based on the developmental progression found here to confirm, if indeed, the sequence remains.

Forth, because we studied very young children's understanding of emotions, we focused on four basic emotions (happy, sad, scared, and angry), which are understood by children at an early age (Widen, 2013). Further research needs to consider these limitations and studies on older children's EU may require inclusion of more complex emotions, such as self-conscious emotions (e.g., guilt, shame, pride and embarrassment) to assess more advanced understanding of emotional displays and the contexts and social relationships in which individuals use and modify emotional expressions.

The EUEC scale in the current study assessed a diverse set of eight EU skills that developed in an ordinal sequence. Although the vast majority of the children in the 1-year-old cohort (13 to 24 months) could not pass the most basic emotion identification

component, a small number of the older children did complete at least 1 and sometimes 2 components, suggesting future studies might consider using identification tasks to assess the beginnings of EU in very young children. Because children acquired two additional EU skills every year, investigators may extract tasks that correspond to the age of the children under study so that possibly only the first four components are administered for children between 1 and 3. Because most parents decide to have a second child when the first is between 1 to 3 years of age, few families with 5- and 6-year-old children could be recruited. Although older children acquired 6 to 8 of the EU components, future research is needed to extend the use of the EUEC up to and perhaps beyond the age of 5 years.

In conclusion, the current study examined the development of firstborn children's EU across three times of measurement using a cohort-sequential design to demonstrate an ordered sequence of EU from basic emotion identification to an understanding of false-belief emotions across ages 1 to 5. Researchers now have a preliminary tool to continue investigations into the progression of children's EU in different populations and across a wider age range to advance an appreciation for individual and cultural variation in the development of EU.

### References

- Banerjee, M. (1997). Hidden emotions: Preschoolers' knowledge of appearance-reality and emotion display rules. *Social Cognition*, 15(2), 107-132.  
<http://dx.doi.org/10.1521/soco.1997.15.2.107>
- Barrett, K. C., & Campos, J. J. (1987). Perspectives on emotional development II: A functionalist approach to emotions. In *Handbook of infant development*, 2nd ed. (pp. 555-578). John Wiley & Sons.
- Bretherton, I., & Beeghly, M. (1982). Talking about internal states: The acquisition of an explicit theory of mind. *Developmental psychology*, 18(6), 906-921.
- Brown, J. R., & Dunn, J. (1996). Continuities in emotion understanding from three to six years. *Child Development*, 67(3), 789-802. doi:10.1111/j.1467-8624.1996.tb01764.x
- Casalin, S., Luyten, P., Vliegen, N., & Meurs, P. (2012). The structure and stability of temperament from infancy to toddlerhood: A one-year prospective study. *Infant*

- Behavior and Development, 35(1), 94-108.
- Castro, V. L., Cheng, Y., Halberstadt, A. G., & Grün, D. (2016). EUREKA! A conceptual model of emotion understanding. *Emotion Review*, 8(3), 258-268. <https://doi.org/10.1177/1754073915580601>
- Cromer, C. C., & Ault, R. L. (1979). Generalization in the receptive and productive language of preschool children. *The Journal of Educational Research*, 73(1), 31-36. <https://doi.org/10.1080/00220671.1979.10885200>
- Cutting, A. L., & Dunn, J. (1999). Theory of mind, emotion understanding, language, and family background: Individual differences and interrelations. *Child Development*, 70(4), 853-865. <https://doi.org/10.1111/1467-8624.00061>
- Denham, S. A. (1986). Social cognition, prosocial behavior, and emotion in preschoolers: Contextual validation. *Child Development*, 57(1), 194-201.
- Denham, S. A., Zoller, D., & Couchoud, E. A. (1994). Socialization of preschoolers' emotion understanding. *Developmental Psychology*, 30(6), 928-936.
- Dunsmore, J. C., & Karn, M. A. (2004). The influence of peer relationships and maternal socialization on kindergartners' developing emotion knowledge. *Early Education and Development*, 15(1), 39-56.
- Eggum, N. D., Eisenberg, N., Kao, K., Spinrad, T. L., Bolnick, R., Hofer, C., ... & Fabricius, W. V. (2011). Emotion understanding, theory of mind, and prosocial orientation: Relations over time in early childhood. *The journal of positive psychology*, 6(1), 4-16. DOI: 10.1080/17439760.2010.536776
- Ensor, R., & Hughes, C. (2005). More than talk: Relations between emotion understanding and positive behaviour in toddlers. *British Journal of Developmental Psychology*, 23(3), 343-363. doi:10.1348/026151005X26291
- Gal-Szabo, D. E., Spinrad, T. L., Eisenberg, N., & Sulik, M. J. (2019). The relations of children's emotion knowledge to their observed social play and reticent/uninvolved behavior in preschool: Moderation by effortful control. *Social Development*, 28(1), 57-73. <https://doi.org/10.1111/sode.12321>
- Gordis, E W., Rosen, A. B., Grand, S. (1989, April). Young children's understanding of simultaneous conflicting emotions. Poster presented at the biennial meeting of the Society for Research in Child Development, Kansas City, MO.

- Halberstadt, A. G., & Eaton, K. L. (2003). A meta-analysis of family expressiveness and children's emotion expressiveness and understanding. *Marriage & Family Review*, 34(1-2), 35-62. [https://doi.org/10.1300/J002v34n01\\_03](https://doi.org/10.1300/J002v34n01_03)
- Harrigan, J. A. (1984). The effects of task order on children's identification of facial expressions. *Motivation and Emotion*, 8(2), 157-169. doi:10.1007/BF00993071
- Harris, P. L. (2006). Social cognition. In W. Damon (Ed.), *Handbook of Child Psychology* (pp. 811–857). New York: Wiley.
- Jones, D. C., Abbey, B. B., & Cumberland, A. (1998). The development of display rule knowledge: Linkages with family expressiveness and social competence. *Child Development*, 69(4), 1209-1222. doi:10.1111/j.1467-8624.1998.tb06168.x
- Klein, M. R., Moran, L., Cortes, R., Zalewski, M., Ruberry, E. J., & Lengua, L. J. (2018). Temperament, mothers' reactions to children's emotional experiences, and emotion understanding predicting adjustment in preschool children. *Social Development*, 27(2), 351-365. <https://doi.org/10.1111/sode.12282>
- Kochanska, G., DeVet, K., Goldman, M., Murray, K., & Putnam, S. P. (1994). Maternal reports of conscience development and temperament in young children. *Child Development*, 65(3), 852-868. doi:10.1111/j.1467-8624.1994.tb00788.x
- Larsen, J. T., To, Y. M., & Fireman, G. (2007). Children's Understanding and Experience of Mixed Emotions. *Psychological Science*, 18(2), 186–191. <https://doi.org/10.1111/j.1467-9280.2007.01870.x>
- Markham, R., & Adams, K. (1992). The effect of type of task on children's identification of facial expressions. *Journal of Nonverbal Behavior*, 16(1), 21-39.
- Molina, P., Bulgarelli, D., Henning, A., & Aschersleben, G. (2014). Emotion understanding: A cross-cultural comparison between Italian and German preschoolers. *European Journal of Developmental Psychology*, 11(5), 592-607.
- Nesselroade, J.R., & Baltes, P.B. (1979). *Longitudinal research in the study of behavior and development*. Academic Press, San Diego, CA.
- O'Brien, M., Miner Weaver, J., Nelson, J. A., Calkins, S. D., Leerkes, E. M., & Marcovitch, S. (2011). Longitudinal associations between children's understanding of emotions and theory of mind. *Cognition and Emotion*, 25(6), 1074-1086. <https://doi.org/10.1080/02699931.2010.518417>

- Pons, F., & Harris, P. (2000). Test of emotion comprehension: TEC. University of Oxford.
- Pons, F., & Harris, P. L. (2019). Children's understanding of emotions or Pascal's "error": Review and prospects. In V. LoBue, K. Pérez-Edgar, & K. A. Buss (Eds.), *Handbook of Emotional Development* (pp. 431-449). Springer International Publishing. [https://doi.org/10.1007/978-3-030-17332-6\\_17](https://doi.org/10.1007/978-3-030-17332-6_17)
- Pons, F., Harris, P. L., & de Rosnay, M. (2004). Emotion comprehension between 3 and 11 years: Developmental periods and hierarchical organization. *European Journal of Developmental Psychology*, 1(2), 127-152. doi: 10.1080/17405620344000022
- Prinz, P., & Onghena, P. (2005). Cohort sequential design. In B. Everitt & D. Howell (Eds.), *Encyclopaedia of statistics in behavioral science* (Vol. 1, pp. 319–322). New York, NY: Wiley. <http://dx.doi.org/10.1002/0470013192.bsa110>
- Rothbart, M. K., & Derryberry, D. (1981). Development of individual differences in temperament. In M. E. Lamb, & A. L. Brown (Eds.), *Advances in developmental psychology* (Vol. 1, pp. 37–86). Hillsdale, NJ: Erlbaum.
- Rothbart, M. K., Ahadi, S. A., Hershey, K. L., & Fisher, P. (2001). Investigations of temperament at 3-7 years: The Children's Behavior Questionnaire. *Child Development*, 72, 1394-1408. doi:10.1111/1467-8624.00355
- Ruby, P., & Decety, J. (2004). How would you feel versus how do you think she would feel? A neuroimaging study of perspective-taking with social emotions. *Journal of Cognitive Neuroscience*, 16(6), 988-999. doi:10.1162/0898929041502661
- Schultz, D., Izard, C. E., Ackerman, B. P., & Youngstrom, E. A. (2001). Emotion knowledge in economically disadvantaged children: Self-regulatory antecedents and relations to social difficulties and withdrawal. *Development and psychopathology*, 13(1), 53-67.
- Shahaeian, A., Peterson, C. C., Slaughter, V., & Wellman, H. M. (2011). Culture and the sequence of steps in theory of mind development. *Developmental Psychology*, 47(5), 1239-1247. <https://doi.org/10.1037/a0023899>
- Tang, Y., Harris, P. L., Pons, F., Zou, H., Zhang, W., & Xu, Q. (2018). The understanding of emotion among young Chinese children. *International Journal of Behavioral Development*, 42(5), 512-517. doi:10.1177/0165025417741366
- Trentacosta, C. J., & Fine, S. E. (2010). Emotion knowledge, social competence, and

- behavior problems in childhood and adolescence: A meta-analytic review. *Social Development*, 19(1), 1-29. <https://doi.org/10.1111/j.1467-9507.2009.00543.x>
- Twenge, J. M., Carter, N. T., & Campbell, W. K. (2017). Age, time period, and birth cohort differences in self-esteem: Reexamining a cohort-sequential longitudinal study. *Journal of Personality and Social Psychology*, 112(5), 9-17.
- Verron, H., & Teglassi, H. (2018). Indirect effects of temperament on social competence via emotion understanding. *Early Education and Development*, 29(5), 655-674.
- Vinden, P. G. (1999). Children's understanding of mind and emotion: A multi-culture study. *Cognition and Emotion*, 13(1), 19-48. doi:10.1080/026999399379357
- Volling, B. L., McElwain, N. L., & Miller, A. L. (2002). Emotion regulation in context: The jealousy complex between young siblings and its relations with child and family characteristics. *Child Development*, 73(2), 581-600. doi:10.1111/1467-8624.00425
- Wechsler, D. (2002). Wechsler Preschool and Primary Scale of Intelligence, 3rd edition (WPPSI-III). San Antonio, TX: Psychological Corporation.
- Wellman, H. M., & Liu, D. (2004). Scaling of theory-of-mind tasks. *Child Development*, 75(2), 523-541. <https://doi.org/10.1111/j.1467-8624.2004.00691.x>
- Wellman, H. M., & Woolley, J. D. (1990). From simple desires to ordinary beliefs: The early development of everyday psychology. *Cognition*, 35(3), 245-275.
- Wellman, H. M., Fang, F., Liu, D., Zhu, L., & Liu, G. (2006). Scaling of theory-of-mind understandings in Chinese children. *Psychological Science*, 17(12), 1075-1081.
- Widen, S. C. (2013). Children's interpretation of facial expressions: The long path from valence-based to specific discrete categories. *Emotion Review*, 5(1), 72-77. doi: 10.1177/1754073912451492
- Youngblade, L. M., & Dunn, J. (1995). Individual Differences in Young Children's Pretend Play with Mother and Sibling: Links to Relationships and Understanding of Other People's Feelings and Beliefs. *Child Development*, 66(5), 1472-1492. <https://doi.org/10.1111/j.1467-8624.1995.tb00946.x>
- Zeman, J., & Garber, J. (1996). Display rules for anger, sadness, and pain: It depends on who is watching. *Child Development*, 67(3), 957-973. <https://doi.org/10.1111/j.1467-8624.1996.tb01776.x>

Table 1

## Number of Children Passing EU Components

		T1	T2	T3
Total N		222	211	195
Age Range in Months		10 - 67	16 - 73	24 - 81
Mean Age in Months (SD)		29.77 (10.21)	35.26 (10.12)	43.43 (10.32)
<u>Ordered Sequence of EU Components</u>	<u>Administered Order</u>	<u>N (Percentage) of Children Passing</u>		
1. Emotion Identification	II	101 (45.50%)	131 (62.09%)	168 (86.15%)
2. Desire Based Emotions	IV	74 (33.33%)	108 (51.18%)	160 (82.05%)
3. Emotion Labeling	I	55 (24.77%)	96 (45.50%)	135 (69.23%)
4. Emotions in Stereotypical Situation	III	46 (20.72%)	68 (32.23%)	101 (51.79%)
5. Emotions in Nonstereotypical Situation	V	33 (14.85%)	64 (30.33%)	98 (50.26%)
6. Emotion Display Rules	VII	15 (6.76%)	26 (12.32%)	46 (23.59%)
7. Mixed Emotions	VIII	9 (4.05%)	11 (5.21%)	32 (16.41%)
8. False Belief Emotions	VI	2 (.90%)	4 (1.90%)	12 (6.15%)

Note. The EU components are ordered based on the number of children who passed each component to reflect the developmental progression of children's EU. The resulting ranking differed from the order of administration that had been based on an initial review of the literature. We administered emotion labeling before emotion identification so as not to expose children to the emotion labels during the identification tasks beforehand and then increase performance on the labeling tasks.



Table 2

Descriptives of the Number of EU Components Passed by Age Groups

Age Group	Mean Age (SD)	n	Number of Components Passed			
			Mean	Median	Min	Max
T1						
< 1 yr:	11.00 (1.41)	2	0	0	0	0
1 yr:	20.00 (2.74)	78	.13	0	0	2
2 yrs:	29.86 (3.46)	83	1.31	1	0	6
3 yrs:	40.78 (3.10)	50	3.28	3	0	7
4 yrs:	53.86 (2.73)	7	5.57	6	4	7
5 yrs:	66.50 (.71)	2	6.50	6.50	6	7
6 yrs:	-	0	-	-	-	-
T2						
< 1 yr:	-	0	-	-	-	-
1 yr:	22.28 (1.85)	29	.17	0	0	2
2 yrs:	30.36 (3.51)	97	1.43	1	0	5
3 yrs:	42.11 (3.28)	65	4.03	4	0	7
4 yrs:	52.62 (4.06)	16	4.56	5	0	7
5 yrs:	65.33 (4.93)	3	7.00	7	6	8
6 yrs:	73 (-)	1	7.00	7	7	7
T3						
< 1 yr:	-	0	-	-	-	-
1 yr:	24 (-)	1	1	1	1	1
2 yrs:	32.96 (2.19)	55	1.98	2	0	7
3 yrs:	41.74 (3.41)	80	3.85	4	0	7
4 yrs:	53.45 (3.37)	49	5.53	5	2	8
5 yrs:	67.00 (3.55)	8	6.00	6.5	4	8
6 yrs:	80.00 (1.41)	2	7.5	7.5	7	8

Notes. < 1yr = 10 – 12 months; 1 yr = 13 – 24 months; 2 yrs = 25 – 36 months; 3 yrs = 37 – 48 months; 4 yrs = 49 – 60 months; 5 yrs = 61 – 72 months; 6 yrs = 73 – 81 months.

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Table 3

## Linear Mixed Models Predicting EU scores using Cohort-Sequential Modeling

	<u>Model 1</u>			<u>Model 2</u>			<u>Model 3</u>		
	B	SE	95% CI	B	SE	95% CI	B	SE	95% CI
Intercept	-.18	.12	[-.42, .06]	-.03	.13	[-.29, .23]	-.09	.13	[-.35, .16]
Verbal Ability							.06**	.01	[.05, .08]
Age	.18**	.01	[.17, .19]	.16**	.01	[.13, .18]	.10**	.01	[.07, .13]
Cohort 2	-.03	.17	[-.36, .30]	-.70**	.24	[-1.18, -.22]	-1.02**	.24	[-1.50, -.54]
Cohort 3	-.26	.23	[-.71, .19]	.14	.44	[-.72., 1.01]	.01	.45	[-.87, .88]
Age x Cohort2				.06**	.02	[.03, .09]	.08**	.02	[.04, .11]
Age x Cohort3				.00	.02	[-.03, .04]	.02	.02	[-.02,.06]
<b>Random Effects</b>									
Intercept	.62			.60			.34		
Residual	1.06			1.04			1.10		

Note. Unstandardized coefficients are presented. EU = The number of EU components passed.

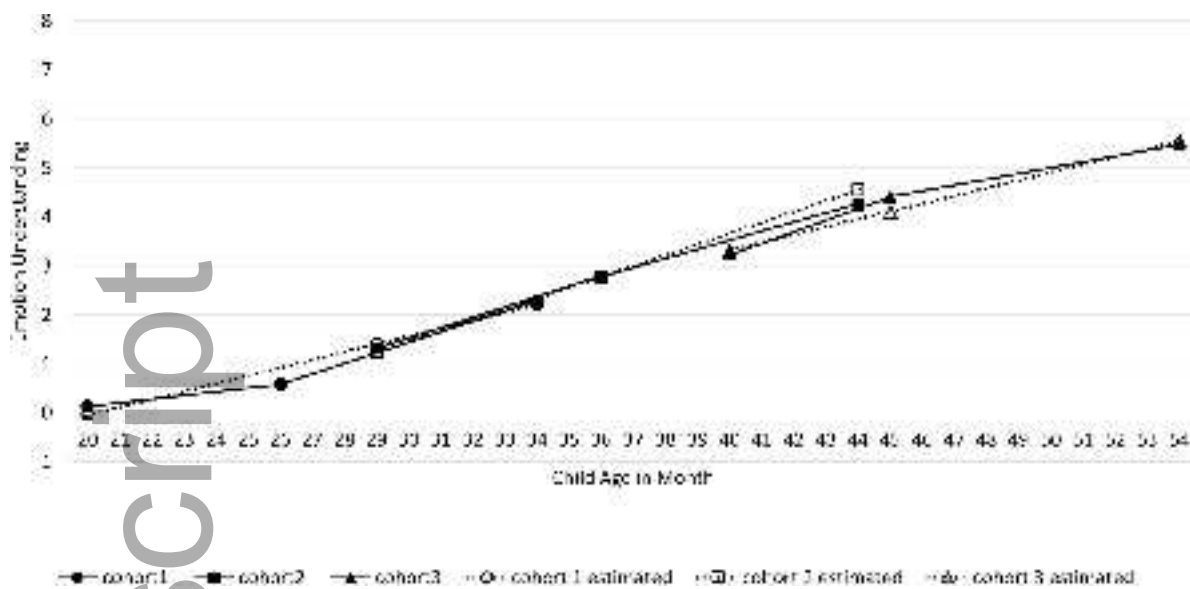
\*  $p < .05$ ; \*\*  $p < .01$ .

Table 4

Test of Validity: Correlations with ToM, Empathy, and Temperament

	ToM (T1)	ToM (T2)	ToM (T3)	Empathy (T1)	Empathy (T2)	Empathy (T3)	Anger (T1)
EU (T1)	<b>.75**</b>	.70**	.65**	<b>.40**</b>	.29**	.19**	<b>.12</b>
EU (T2)	.64**	<b>.63**</b>	.66**	.42**	<b>.25**</b>	.09	.15*
EU (T3)	.65**	.58**	<b>.66**</b>	.38**	.32**	<b>.23**</b>	.16*
<u>Controlling for Age and Verbal Ability</u>							
EU (T1)	<b>.31**</b>	.23**	.25**	<b>.15</b>	.07	.14	<b>-.03</b>
EU (T2)	.02	<b>.16*</b>	.26**	.19*	<b>.10</b>	.05	.09
EU (T3)	.18*	.14	<b>.31**</b>	.09	.19*	<b>.11</b>	.10

Note. \*  $p < .05$ ; \*\*  $p < .01$ . EU = The number of EU components passed; ToM = Theory of Mind. Concurrent correlations are bolded.



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