Beliefs about the development of mental life

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Abstract

In a series of large-scale studies we assessed how US adults conceptualize the development of the human mind over the first five years of life. Exploratory factor analysis identified four categories of mental capacities that anchored participants' representations of the developing human mind: *bodily sensations* (e.g., hunger, pain), *negative affect* (e.g., distress, frustration), *social connection* (e.g., love, learning from others), and *cognition and control* (e.g., planning, self-control). Participants perceived that these four aspects of mental life were present to different degrees at birth, followed different developmental trajectories, and were driven by different developmental mechanisms (such as biological "preprogramming," physical maturation, passive observation, and social learning). These studies reveal the intuitive theories that govern US adults' understanding of the development of the human mind, illuminating the cognitive architecture that supports some of the most important social interactions: caregiving relationships with infants and children.

Significance statement

Caregiving relationships with infants and children are among the most common, important, and complex human social interactions. Caring for a young child over time requires an adult to continually update their own mental representations of the child's capacities as the child grows and changes. These representations are likely to have important consequences for the child's well-being—particularly in the first few years of life, when the child's communication skills are limited and the caregiver must make inferences about the child's thoughts, feelings, and needs. The current studies shed light on this fascinating and understudied aspect of "mind perception," in turn laying the foundation for theory-based interventions to encourage positive and responsive parenting behaviors.

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Frustration, compassion, worry, humor, imagination, love—such experiences are fundamental parts of human life. But few people would assert that these capacities are fully developed at birth. In any given interaction with a child, adults come face to face with a being whose experience of the world is like their own, but different; whose mind is capable of some of the thoughts and feelings that an adult's mind is, but perhaps not all of them. When an adult interacts with the same child over time, they witness innumerable changes in that child's mental life: A sleepy newborn gradually becomes a child who experiences complex emotions and original ideas and develops personal memories and intricate plans. This familiar but remarkable transformation requires adults to make inferences about a given child's developing mental capacities in order to interpret that child's behaviors and respond appropriately.

In this paper, we examine how adults conceptualize the developing minds of infants and children. We draw on techniques developed in studies of mind perception, in which researchers use large datasets and modern statistical methods to reveal conceptual representations of "the mind," broadly construed. In a groundbreaking study, Gray et al. asked participants to compare the mental capacities of a range of humans, animals, technologies, and other entities, and argued that participants' judgments revealed a fundamental distinction between "agency" (e.g., capacities for self-control, moral reasoning, memory, and planning) and "experience" (e.g., capacities for hunger, fear, pain, and pleasure) (Gray, Gray, and Wegner 2007). More recently, Weisman et al. used a similar empirical approach to argue that people's conceptions of mental life are anchored by three fundamental components: "body" (physiological sensations such as hunger and pain), "heart" (social-emotional abilities such as embarrassment and pride), and "mind" (perceptual-cognitive capacities such as vision and memory (Weisman, Dweck, and Markman 2017b); see (Malle 2019) for a similar three-factor solution. Such findings have inspired subsequent work on topics as wide-ranging as moral reasoning, dehumanization and stereotyping, beliefs about the afterlife, and human-robot interactions.

However, the burgeoning field of mind perception has largely neglected the question of how the human mind emerges over development. In many studies, infants and children have simply not been included as targets for mental capacity attributions; instead, participants have been asked to reason about human adults alongside a range of non-human entities, including other animals, technologies, and supernatural beings. Even studies that have probed participants' mental capacity attributions to infants and children have generally treated them as beings distinct from adults, rather than as snapshots of a single mind as it emerges and changes over time. For example, Gray et al.'s early work on mind perception suggested that a five-month-old infant is an entity that is generally considered to have experience but not agency—in contrast to, say, a five-year-old child (considered to have experience as well as limited agency), a human adult (considered to have maximal experience and agency), or a robot (considered to have agency but not experience) (Gray, Gray, and Wegner 2007). Likewise, Weisman et al.'s studies characterized infants and young children—along with, e.g., chimpanzees, elephants, and dolphins—as entities that are perceived to be fully capable of physiological sensations but more limited in their perceptual-cognitive capacities and social-emotional abilities; this is in contrast to human adults, who are perceived to be fully capable across these domains (Weisman, Dweck, and Markman 2017b). Although such findings can be reinterpreted as providing preliminary evidence that people consider the minds of infants and children to differ from the minds of adults, they do not address how people conceptualize the development of the mind in early life.

Yet infants and young children are far from unusual social partners. Caregiving relationships are at the core of human existence; for many people, infants and young children are among the most frequent and highly valued minds that we encounter. Caring for a young child involves making countless decisions under uncertainty: Why is my child crying, smiling, shouting, or biting? Can they understand what I am saying? Does my child love me? As in other domains of reasoning (Gerstenberg and Tenenbaum 2017; Gopnik and Wellman 1994; Wellman and Gelman 1992), people likely draw on folk beliefs and intuitive theories about how the mind develops to predict, explain, and respond to children's behavior and development, with consequences for the well-being of children in their care.

In the current studies we set out to investigate this important and understudied aspect of mind perception: how ordinary people reason about the development of human mental life. In three studies, we assessed US adults' folk beliefs about children's developing abilities for physiological sensation, perception, cognition, emotion, self-regulation, social interaction, and other aspects of "mental life," broadly construed. We focused on development between birth and age five years—a time of particularly dramatic maturation in

perceptual acuity, emotional experience, cognitive ability, executive function, social engagement, and many other domains.

Results

Study 1

We began with an expansive exploration of US adults' attributions of mental life to infants and young children of different ages. Drawing inspiration from previous work on mind perception (Gray, Gray, and Wegner 2007; Weisman, Dweck, and Markman 2017b, 2017a, 2018) as well as standard assessments of infant temperament and behavior (Putnam, Gartstein, and Rothbart 2006; Rothbart 1978), we included a wide range of 60 capacities in this initial exploration, from basic physiological sensations, to capacities for perception, cognition, and emotion, to abilities for self-regulation and social interaction. We asked participants ($n = 301$) to assess these capacities at three different ages (at birth, 9 months, and 5 years), with the goal of characterizing the conceptual structure underlying participants' reasoning about the development of mental life: What do people perceive to be the fundamental components of mental life, as they pertain to a developing human child?

We designed Study 1 to explore the correlational structure of participants' responses, as a window into the underlying conceptual structure that might support their reasoning about the development of mental life. Our primary analysis for this preregistered study was an exploratory factor analysis (EFA) of participants' capacity ratings. This analysis allowed us to examine which capacities tend to "hang together" in participants' assessments of the mental lives of infants and young children. For example, when a participant indicated that newborns are highly capable of feeling scared, what other capacities did they tend to attribute to newborns? Following previous work on mind perception, we argue that the suites of capacities revealed by applying dimensionality reduction (in our case, EFA) to this covariance structure offer a meaningful approximation of the latent conceptual structure underlying participants' reasoning about the developing human mind.

A 4-factor solution (as suggested by parallel analysis) accounted for 72% of the total variance in participants' capacity attributions. See Figure 1 for all factor loadings after oblique transformation.

The first factor corresponded primarily to capacities related to thinking, reasoning, agency, and executive function—a suite of capacities that we will refer to as *cognition and control*. It was the dominant factor for such items as "planning," "having self-control," "thinking before they act," "having goals," "reasoning about things," "controlling their emotions," "telling right from wrong," and "understanding what somebody else is thinking," and accounted for 38% of the shared variance in the rotated 4-factor solution and 27% of the total variance in participants' capacity attributions.

The second factor corresponded primarily to social abilities and emotional experiences, particularly those with positive valence—a suite of capacities that we will refer to as *social connection*. It was the dominant factor for such items as "feeling excited," "finding something funny," "loving somebody," "learning from other people," "feeling happy," "feeling loved," "recognizing somebody else," and "getting pleasure from music," and accounted for 33% of the shared variance in the rotated 4-factor solution and 24% of the total variance in participants' capacity attributions.

The third factor corresponded primarily to physiological sensations related to biological needs—a suite of capacities that we will refer to as *bodily sensations*. It was the dominant factor for such items as "getting hungry," "feeling pain," "feeling tired," "feeling thirsty," "feeling too hot or too cold," "feeling physically uncomfortable," "hearing sounds," and "being comforted by physical touch," and accounted for 19% of the shared variance in the rotated 4-factor solution and 14% of the total variance in participants' capacity attributions.

Finally, the fourth factor corresponded to negatively-valenced sensations and emotions—a suite of capacities that we will refer to as *negative affect*. It was the dominant factor for the items "feeling helpless," "feeling overwhelmed," "feeling frustrated," "feeling annoyed," and "feeling neglected"; the items "feeling distressed,"

"feeling confused," "feeling worried," and "feeling lonely" also loaded relatively strongly on this factor (albeit slightly more strongly on other factors). This factor accounted for 10% of the shared variance in the rotated 4-factor solution and 7% of the total variance in participants' capacity attributions.

How robust are these findings? The factors we have called *bodily sensations*, *social connection*, and *cognition and control* each had strong factor loadings (≥ 0.60) for many individual items (n = 8-16) and each accounted for a substantial amount of the total variance in participants' capacity attributions (14-27%), indicating three robustly distinct and interpretable factors. In contrast, the fourth factor—*negative affect*—had more moderate loadings even for its strongest-loading items (all loadings < 0.46) and accounted for only 7% of the total variance. Nonetheless, we consider the general domain of *negative affect* to be of particular theoretical and clinical interest.

What does it mean that these four factors emerged? At a most basic level, our results reflect sets of intercorrelated capacities: When a participant judged that a child of a certain age was highly capable of planning, they also tended to judge that that child was capable of having self control, thinking before they act, and the other capacities with strong factor loadings on the *cognition and control* factor; and likewise for the suites of capacities that define the other factors revealed by EFA. Therefore, we take these factors to reflect latent constructs—fundamental components of mental life relevant to reasoning about human children. Moreover, because each participant was asked to reason not just about some class of target characters (e.g., "chimpanzees," "robots"), but about the human child over development, we further propose that part of what contributed to the differentiation of these four factors was participants' perceptions of development: the extent to which different capacities are present at birth, the rate at which different capacities develop, and the mechanisms that drive this development. In Studies 2 and 3, we explore these possibilities in greater depth.

Study 2

In Study 2 ($n = 304$), we replicated the conceptual structure identified by Study 1 and then used it to chart how different aspects of mental life are perceived to change over development: What kinds of abilities do people believe are present at birth, and to what degree? To what extent are capacities for *bodily sensations*, *negative affect*, *social connection*, and *cognition and control* perceived to change over childhood, and what is the shape of this perceived developmental trajectory?

The design of Study 2 was nearly identical to Study 1, except that instead of assessing 60 capacities for 3 target ages, each participant assessed 20 capacities for 13 target ages: birth, 4 days, 1 month, 2 months, 4 months, 6 months, 9 months, 12 months, 18 months, 2 years, 3 years, 4 years, and 5 years (see Methods). This design allowed us to chart perceived developmental trajectories with a high degree of precision without undue burden to participants.

A preregistered EFA yielded four factors very similar to the four factors from Study 1, with all capacity items loading strongly on the factors that they were selected to represent and less strongly on other factors (see Supplemental Materials). Minimally, this suggests that our selection of mental capacities for this study captured the essential meaning of the four factors revealed in Study 1. Beyond this, we consider these results to be a somewhat independent conceptual replication of Study 1 results and validation of our interpretation of these factors. After all, given that Study 2 featured only 20 of the 60 capacities featured in Study 1, it certainly could have been the case that this analysis would suggest retaining fewer factors (as often occurs with fewer variables). Conversely, given that Study 2 featured 13 within-subjects observations for each capacity compared to the 3 in Study 1, this analysis could have surfaced more than four factors (as often occurs with more observations). Finally, if we had misinterpreted the fundamental semantic content that distinguished the factors in Study 1 and selected inappropriate capacities to represent these factors, the Study 2 analysis could have identified more capacities with cross-loadings. Instead, the results of this analysis offer some validation of the four factors we have called *bodily sensations*, *negative affect*, *social connection*, and *cognition and control*.

Regressing participants' item-level responses onto target age, domain, and interactions between them via a multilevel generalized additive model confirmed both of our preregistered hypotheses: On average, par-

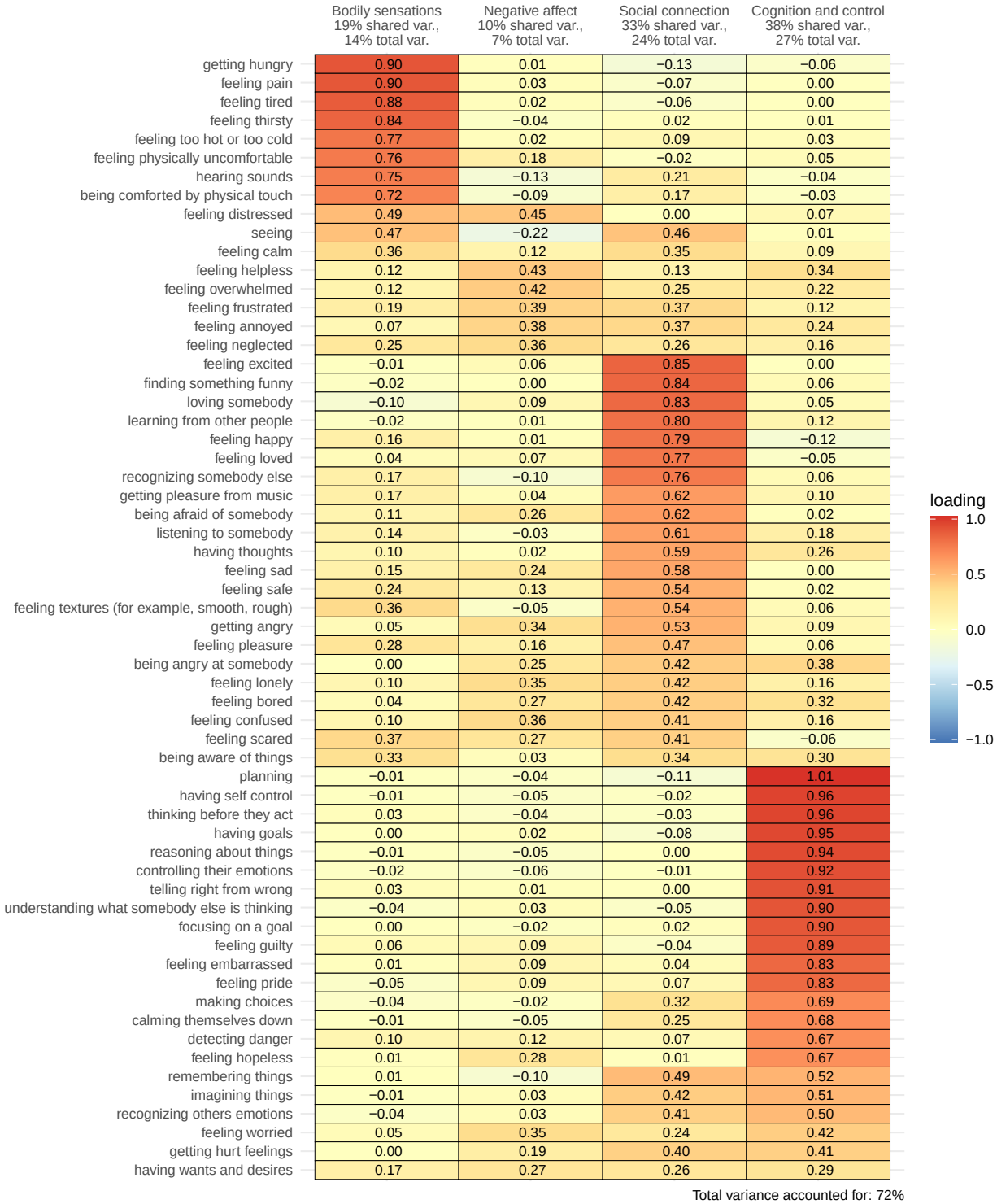

Figure 1: Factor loadings from an exploratory factor analysis of participants' capacity attributions to newborns, 9-month-old infants, and 5-year-old children in Study 1.

ticipants rated older children as more capable, but perceptions of the development of children's capacities differed dramatically across domains. On one extreme, participants attributed some, but relatively little, capacity for *cognition and control* to newborns (median score for newborns: 1.00 out of 100 points, $M = 8.24$, $sd = 18.61$), but reported that such capacities increase dramatically over the target age range (average smoothing term, analogous to a slope in linear regression: $F = 3396.88$, $p < 0.001$, $edf = 8.13$). Compared to these attributions of *cognition and control*, participants attributed substantially greater capacities to newborns in the domains of *social connection* (median score for newborns: 45.00 out of 100 points, $M = 46.06$, $sd = 37.30$; increase in log-odds relative to *cognition and control*: $\beta = 3.13$, $p < 0.001$) and *negative affect* (median score for newborns: 63.50 out of 100 points, $M = 56.24$, $sd = 38.04$; increase in log-odds: $\beta = 3.05$, $p < 0.001$) and, accordingly, reported relatively small increases over the target age range in both domains (average smoothing terms for *social connection*: $F = 2351.32$, $p < 0.001$, $edf = 8.63$; for *negative affect*: $F = 1535.93$, $p < 0.001$, $edf = 8.13$). At the other extreme, in the domain of *bodily sensations* participants attributed nearly maximal capacity to newborns (median score for newborns: 100.00 out of 100 points, $M = 86.42$, $sd = 24.28$; increase in log-odds relative to *cognition and control*: $\beta = 4.82$, $p < 0.001$) and a significant but small increase in capacities for *bodily sensations* over the target age range (average smoothing term: $F = 364.84$, $p < 0.001$, $edf = 6.07$).

Visual inspection of Figure 2, Panel A, clearly illustrates that the shape of perceived growth in children's capacities varied substantially across domains. In the domain of *bodily sensations*, participants perceived hardly any growth over the target age range, and what growth they did perceive occurred in the first year of life. Participants perceived development in the domains of *negative affect* and *social connection* to be quite non-linear, characterized by rapid development over the first 1-2 years of life, at which point the curves level off dramatically. In contrast, participants perceived dramatic development in the domain of *cognition and control*, but perceived this development to unfold fairly steadily across the full age range.

We speculate that these differences in perceptions of growth in children's capacities emerge from intuitive theories of development that specify different mechanisms or drivers of development for different domains. For example, if participants believe that development in the domain of *bodily sensations* is primarily driven by innate biological forces, they might assume that most of this development is complete before birth, leaving little room for change over the target ages assessed (see Berent, Platt, and Sandoboe (2019) for empirical evidence in line with this speculation). In contrast, in a domain where participants believe development depends on observation, exploration, or social learning, they might think that children need time in the world to change and grow, yielding lower estimates of capacities at birth and slower estimates of rates of change; or, in a domain where participants believe that development occurs through explicitly teaching the child something, they might perceive that development proceeds nonlinearly, such that large changes occur following specific milestones (e.g., entry to preschool). We explore this possibility in Study 3.

Study 3

Study 3 was designed with two goals in mind: First, we aimed to provide a more direct assessment of the differences in perceived developmental trajectories surfaced by Study 2. Second, we aimed to probe the intuitive theories that might underlie the differentiation of the four factors surfaced by Studies 1-2 and the perceived developmental trajectories surfaced by Study 2 (and the current study).

Perceived developmental trajectories

In Study 2, participants focused on one target age at a time, assessing a variety of capacities for that age before proceeding to the next target age (from youngest to oldest). This design was intended to encourage participants to focus primarily on providing a holistic assessment of mental life at a given target age; the trajectories connecting target ages were likely not the participants' primary concern in the moment of responding. In Study 3, we flipped the design to focus participants' attention on development more explicitly: Participants were asked to provide judgments of a single capacity for the full range of target ages (arranged from youngest to oldest) on the same "trial," before proceeding to the next capacity. In addition to signaling more strongly to participants that we were interested in their perceptions of development, this approach

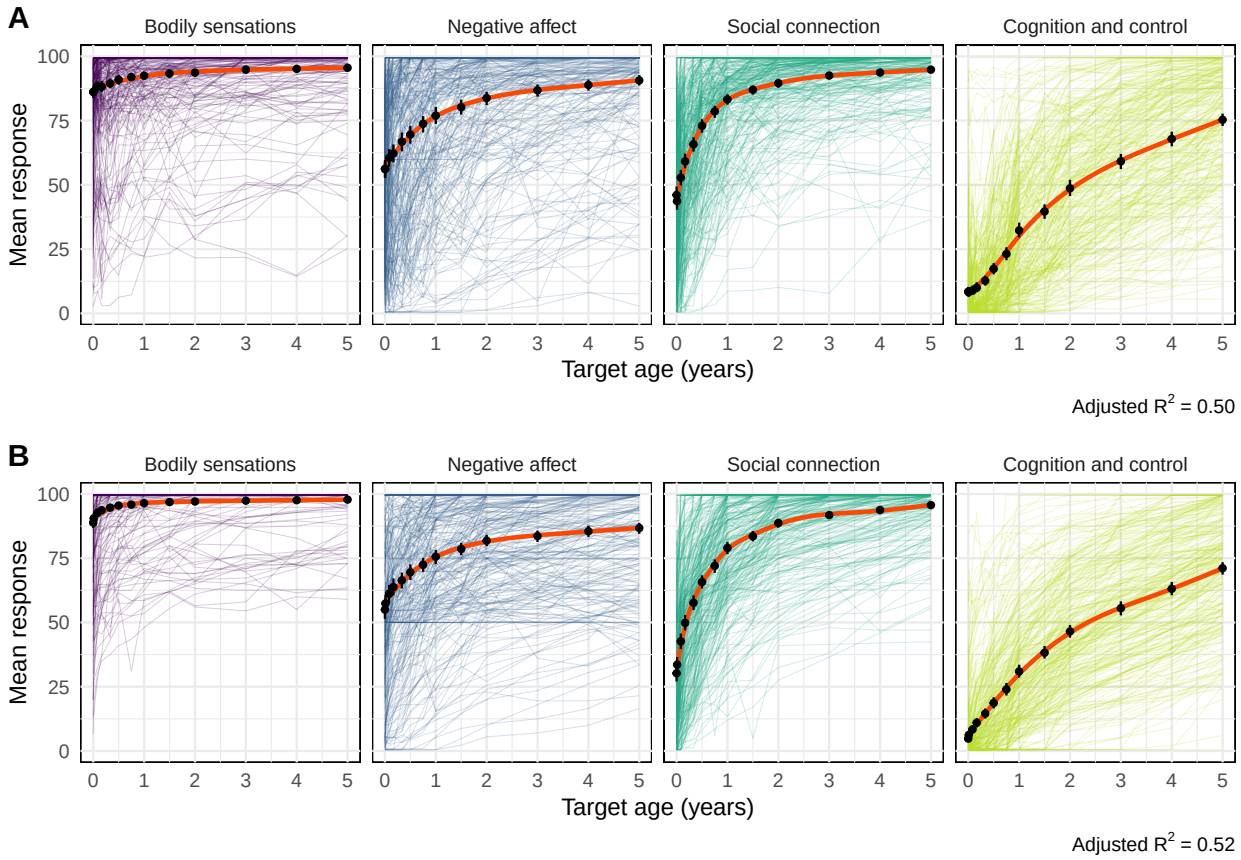

Figure 2: Perceived developmental trajectories for four domains of mental life (Studies 2-3). Lighter lines represent individual participants' responses, black points correspond to mean responses across the sample, error bars are bootstrapped 95% confidence intervals, and thick red lines are predictions from our generalized additive models (beta regressions). In Study 2 (Panel A), participants assessed 5 capacities within each domain, and assessed all capacities for a given target age before moving on to the next target age. In Study 3 (Panel B), participants assessed 2 capacities within each domain, and assessed a single capacity for all target ages before moving on to the next capacity.

gave participants the opportunity to view and adjust all of their responses for a given target capacity simultaneously, charting out their perceptions of the full developmental trajectory from birth to age 5 years. In order to accommodate the addition of questions probing intuitive theories of development (see next section), participants assessed only 2 capacities per domain; see Methods.

This approach yielded a very similar picture of US adults' understanding of the development of human mental life; see Figure 2, Panel B. As in Study 2, participants perceived that newborns have very little capacity for *cognition and control* (median score for newborns: 0.00 out of 100 points, $M = 4.49$, $sd = 12.69$), but reported that such capacities increase dramatically over the target age range (average smoothing term: $F = 1782.20$, $p < 0.001$, $edf = 8.45$). Again, participants attributed substantially greater capacities to newborns in the domains of *social connection* (median score for newborns: 10.00 out of 100 points, $M = 30.16$, $sd = 35.74$; increase in log-odds: $\beta = 3.15$, $p < 0.001$) and *negative affect* (median score for newborns: 60.00 out of 100 points, $M = 55.10$, $sd = 42.02$; increase in log-odds: $\beta = 3.49$, $p < 0.001$); in Study 3, as in Study 2, participants reported relatively small increases over the target age range in the domain of *negative affect* (average smoothing term: $F = 748.53$, $p < 0.001$, $edf = 8.45$), but in this case they reported quite dramatic increases in the domain of *social connection* ($F = 1744.70$, $p < 0.001$, $edf = 8.85$). Finally, as in Study 2, in the domain of *bodily sensations* participants attributed nearly maximal capacity to newborns (median score for newborns: 100.00 out of 100 points, $M = 89.21$, $sd = 23.20$; increase in log-odds relative to *cognition and control*: $\beta = 6.00$, $p < 0.001$) and a significant but small increase in capacities for *bodily sensations* over the target age range (average smoothing term: $F = 175.99$, $p < 0.001$, $edf = 8.13$).

Visual inspection of Figure 2, Panel B, makes it clear that the shape of these perceived developmental trajectories varied substantially across domains, echoing quite precisely the results of our post-hoc exploratory analyses in Study 2.

Intuitive theories of development

Why do people believe certain aspects of mental life, but not others, to be present at birth? What do people perceive to be driving the development of capacities for *bodily sensations*, *negative affect*, *social connection*, and *cognition and control*? As a first step in what we hope to be a longer line of work addressing such questions, we asked participants to assess the importance of a variety of possible developmental mechanisms for each of the capacities included in this study. We theorized that when people perceive that a capacity is substantially present at birth, they believe that the capacity is innate, and, conversely, that when people perceive that a capacity develops slowly over years, they believe the capacity is in some sense learned. (See Wang (2019); Berent, Platt, and Sandoboe (2019); Berent, Feldman Barrett, and Platt (2020) for in-depth investigations of ordinary people's intuitions about the innateness of cognitive abilities, motor abilities, and emotion.)

We assessed a wide range of potential developmental mechanisms for children's capacities, and gave participants opportunities to endorse nuanced, even internally inconsistent theories of development, by having them assess each of these developmental mechanisms for each capacity independently in addition to selecting the "most important" mechanism via forced choice.

A variety of dimensionality reduction techniques converged to suggest that participants perceived the ten developmental mechanisms we included in this study as falling into two general categories (see Supplemental Materials). First, there were what we will call *intrinsic mechanisms*, including those whose influence occurs prior to a child's birth ("the child is biologically 'preprogrammed' to have this ability," "the child has experiences in the womb that give them this ability") and those whose influence continues into infancy and childhood ("the child's body grows and matures [for example, muscles get stronger, child gets taller]," "the child's senses improve [for example, vision gets sharper, hearing improves]"). Participants clearly distinguished these intrinsic mechanisms from what we will call *extrinsic mechanisms*, which included both passive forms of learning ("the child observes the objects and the physical world around him or her," "the child observes the people around him or her," "the child interacts with the people around him or her") and more active forms of learning ("people explicitly teach the child how to do this," and "the child actively experiments with how to do this"). One mechanism—"the child's brain changes (for example, brain grows

bigger, more or fewer connections between neurons)"—was difficult to categorize as "intrinsic" or "extrinsic," with different analyses suggesting different conclusions; indeed, on its face this item is more ambiguous and could refer both to intrinsic maturational processes and to the effects of external experiences influencing brain circuitry. This item was eliminated from the analyses that follow (but included in the visualizations presented in Figure 3).

A multilevel linear regression suggested that, collapsing across domains, intrinsic and extrinsic mechanisms were rated as equally important (median score for intrinsic mechanisms: 2.78 on a scale from 0-6, $M = 2.81$, $sd = 1.00$; median score for extrinsic mechanisms: 3.35 on a scale from 0-6, $M = 3.38$, $sd = 0.97$; comparison: $\beta = 0.13$, 95% CI: [-0.07, 0.33], $p = 0.215$), but that the difference between intrinsic and extrinsic mechanisms varied across domains (interaction terms: $|\beta|$ ranged from 0.16-0.50, all $p < 0.001$).

For capacities in the domain of *bodily sensations*, participants rated intrinsic mechanisms as much more important drivers of development than extrinsic mechanisms (median of participant-level mean differences: -1.77 out of a maximum difference of $\pm$ 6 points, M_{diff} = -1.67, sd = 1.18; comparison to 0 in separate multilevel regression model: β = -0.36, 95% CI: [-0.63, -0.08], p= 0.010). In the domain of *negative affect*, participants rated intrinsic and extrinsic mechanisms as equally important (median of participant-level mean differences: 0.35, $M_{diff} = 0.32$, $sd = 1.23$; comparison to 0 in separate multilevel regression model: $\beta = 0.07$, 95% CI: [-0.19, 0.34], p= 0.584). In the domain of *social connection*, participants rated extrinsic mechanisms as more important (median of participant-level mean differences: 1.25, M_{diff} = 1.29, sd = 1.10; comparison to 0 in separate multilevel regression model: $\beta = 0.31$, 95% CI: [0.06, 0.56], p= 0.016), and this was even more the case for capacities in the domain of *cognition and control* (median of participant-level mean differences: 2.38, M_{diff} = 2.34, sd = 1.42; comparison to 0 in separate multilevel regression model: $\beta = 0.56$, 95% CI: [0.35, 0.76], p< 0.001). See Figure 3, panels A-B, for a visualization of these differences, and Supplemental Materials for the full results of these analyses.

Participants' intuitions that different aspects of mental life are driven by different mechanisms were also reflected in their responses to the forced-choice questions about the "most important" factor driving the development of each of these capacities; see Figure 3, Panel C. Participants overwhelmingly chose intrinsic mechanisms for capacities in the domain of *bodily sensations* (94% of all responses), and also tended to choose intrinsic mechanisms for capacities in the domain of *negative affect* (52% of responses, compared to 28% extrinsic choices; the remaining response fell outside of this categorization scheme). On the whole, participants demonstrated no strong preference for intrinsic or extrinsic mechanisms in the domain of *social connection* (32% intrinsic choices, compared to 45% extrinsic choices). Finally, participants tended to choose extrinsic mechanisms for capacities in the domain of *cognition and control* (53% of responses, compared to 12% intrinsic choices).

Taken together, we would argue that participants' responses were consistent with the following intuitive theory: In all aspects of mental life, development is driven by a combination of intrinsic and extrinsic mechanisms, but the relative importance of these mechanisms varies across domains. Capacities for *bodily sensations* are shaped primarily by intrinsic biological mechanisms, such as biological "preprogramming"; in other words, they are largely innate. Conversely, the development of capacities for *cognition and control* is driven primarily by extrinsic mechanisms, i.e., by observing and interacting with the world. Capacities in the more social-emotional aspects of mental life are intermediate between these extremes, with both intrinsic and extrinsic mechanisms exerting substantial influence; but capacities for *social connection* might be distinguished from capacities for *negative affect* by their heightened sensitivity to extrinsic mechanisms (in particular, observing and interacting with other people).

Discussion

In a series of three large-scale studies, we identified four distinct suites of mental capacities that are perceived by US adults to develop over human infancy and early childhood, *bodily sensations*, *negative affect*, *social connection*, and *cognition and control* (Study 1); measured perceptions of these capacities at birth and charted how they are perceived to change over the first five years of a child's life (Studies 2-3); and explored

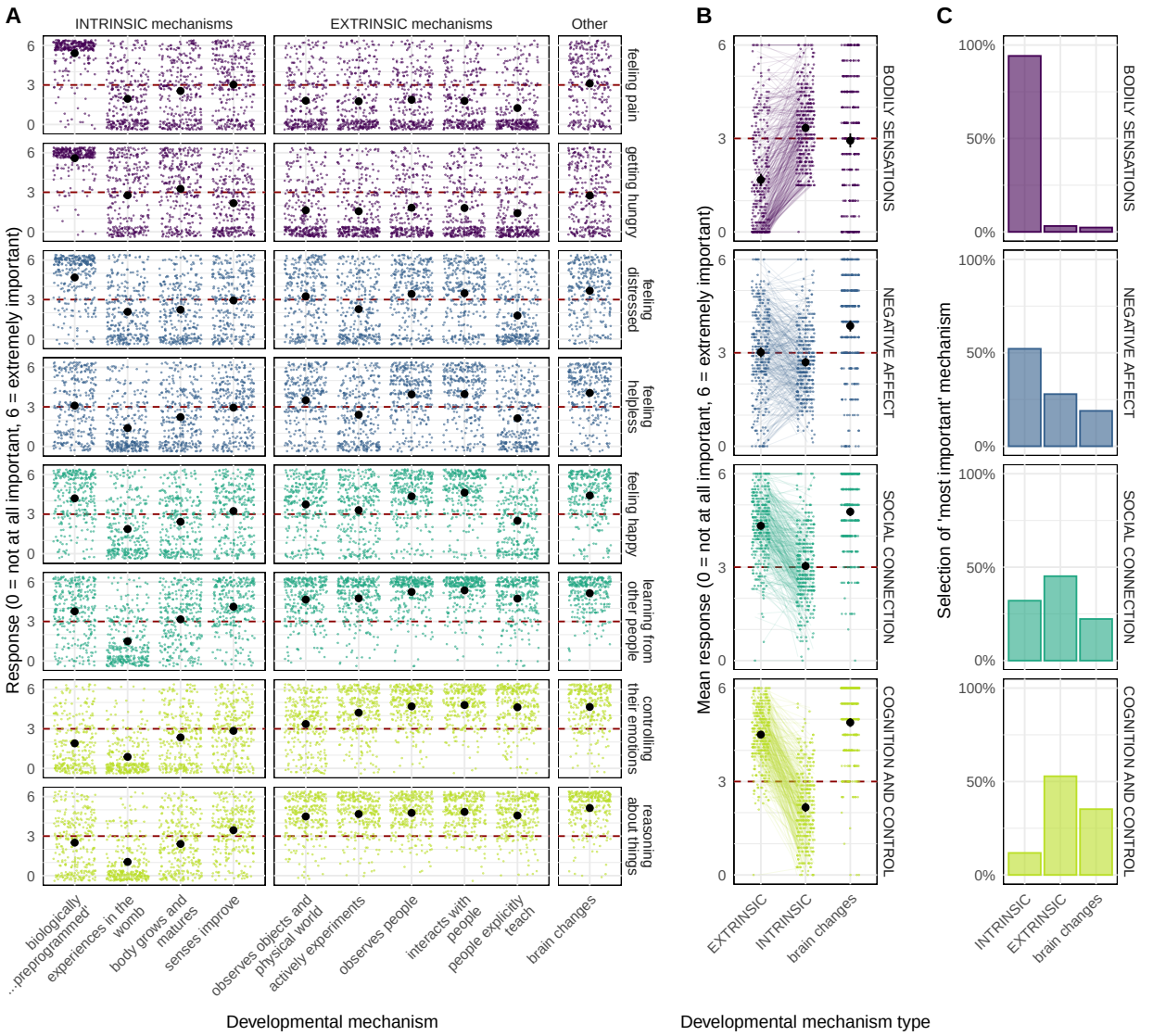

Figure 3: Perceived importance of various mechanisms in the development of four domains of mental life (Study 3); see main text for the full text of each mechanism. Panel A shows ratings for each developmental mechanism and both of the capacities within each domain; Panel B shows mean ratings for extrinsic vs. intrinsic mechanisms for each domain of capacities; and Panel C shows the percentage of trials on which participants selected extrinsic vs. intrinsic mechanisms as the 'most important' driver of development. Lighter points and lines represent individual participants' responses, black points correspond to mean scores across the sample, and error bars are bootstrapped 95% confidence intervals. The dotted red line at the midpoint of the response scale in Panels A and B is intended to aid visual comparison across domains.

the intuitive theories that underlie the observed differences in the perceived developmental trajectories of these four aspects of mental life (Study 3).

We found that participants considered *bodily sensations* (e.g., hunger, pain) to be present from very early in an infant's life—in many cases, "preprogrammed" and present at birth—leaving relatively little room for development over childhood. In contrast—and in line with previous work on adults' intuitions about cognitive development (Wang 2019; Berent, Platt, and Sandoboe 2019)—participants considered capacities for *cognition and control* (e.g., planning, self-control) to be largely absent at birth and to develop steadily and gradually over the first five years of life, driven primarily by what we called "extrinsic" mechanisms (e.g., observations and interactions with other people, explicit teaching, and active exploration on the part of the child).

Beliefs about the development of the more social-emotional aspects of mental life—*negative affect* (e.g., distress, frustration) and *social connection* (e.g., love, learning from others)—were intermediate between the extremes of *bodily sensations* and *cognition and control*. In the aggregate, participants considered capacities for *negative affect* and *social connection* to be present to some degree, but not fully, from birth; and to develop rapidly in the first two years of life before tapering off. Likewise, participants reported that development in these capacities was driven by a *combination* of the extrinsic mechanisms just described and more "intrinsic" mechanisms, such as physical maturation and "preprogramming." Both in their perceptions and in their explanations of development, participants' understanding of *negative affect* were somewhat more similar to their responses to capacities for *bodily sensations*, while their responses to capacities for *social connection* more closely resembled their understanding of *cognition and control*. We note that attributions of *negative affect* and *social connection* were particularly variable across individual participants, especially when it came to perceptions of the capacities of newborns; see Figure 2. This suggests that beliefs about development in these domains are especially sensitive to personal experience, social-cultural context, explicit education, or other forms of input.

In some respects, the results of these studies resonate well with previous work on mind perception among US adults. The factors that we refer to as *bodily sensations* and *cognition and control* highlight a sharp distinction between embodied, physiological experiences and the more cognitive and agentic aspects of mental life experiences—reminiscent of previous distinctions between "experience" and "agency" (Gray, Gray, and Wegner 2007), between "body" and "mind" (Weisman, Dweck, and Markman 2017b), and between "affect" and "regulation" (Malle 2019). These two factors were clearly evident in all of the factor solutions we examined, providing further evidence that this distinction is a particularly important aspect of how US adults reason about mental life. (See also Weisman et al. (2021) for evidence that a distinction between bodily sensation and cognition is held in common across diverse cultural settings.)

However, these studies also highlight one way in which reasoning about the development of human mental life may diverge from reasoning about mental life in general: In their assessments of the mental lives of infants and children at different ages, participants differentiated between what we call *social connection* (e.g., capacities for excitement, humor, and love) and what we call *negative affect* (e.g., capacities for distress, helplessness, and frustration). These two factors have no obvious precedents in previous studies of mind perception. In the agency-experience framework (Gray, Gray, and Wegner 2007), *negative affect* would likely fall under the umbrella of "experience," but *social connection* seems to combine aspects of both "experience" (e.g., happiness, sadness) and "agency" (e.g., learning, recognition); similarly, in Malle's (2019) framework (Malle 2019), *negative affect* clearly resonates with "affect," but *social connection* seems to combine aspects of both "regulation" and "reality interaction." Meanwhile, in the body-heart-mind framework (Weisman, Dweck, and Markman 2017b), *social connection* and *negative affect* might both be considered part of the social-emotional domain of the "heart." This difference from previous work could have many (or multiple) causes, including the wider range of capacities included in this study (in particular, the inclusion of capacities for feelings of helplessness, frustration, annoyance, neglect, loneliness, boredom, confusion, and being overwhelmed; see Supplemental Materials); the narrower focus on humans as the targets of mind perception; or the emphasis on how mental capacities develop over time. Based on the findings of Studies 2 and 3, we propose that *social connection* and *negative affect* emerged as distinct factors because participants believed these two aspects of mental life develop differently: i.e., that they are present to different degrees at birth, develop at different rates over infancy and childhood, and are driven by different developmental mechanisms.

What do these studies reveal about US adults' understanding of the contributions of nature vs. nurture to the development of human mental life? One consistent finding across these studies is that participants attributed many capacities to newborns, at least to a moderate degree. In addition to *bodily sensations* and *negative affect*—obvious aspects of a newborn's experience of the world—participants also reported that newborns had fairly substantial social-cognitive abilities, including, critically, "learning from other people." Indeed, in Study 4 participants considered biological "preprogramming" to play a rather important role in the ability to learn from other people, and to have some non-trivial impact even on the most purely cognitive ability included in that study, reasoning about things (see Figure 3). Rather than "intuitive empiricists" (Wang 2019; Berent, Platt, and Sandoboe in press), then, US adults might be better described as "intuitive constructivists" who viewed newborns as predisposed and innately equipped to learn from the people around them.

Adults' intuitive theories are likely to have important consequences for the children in their care (Haimovitz and Dweck 2016; Hembacher and Frank 2020; Mukhopadhyay and Yeung 2010). We suspect that intuitive theories of the development of mental life could play a particularly important role in the quality of caregiver–child relationships in the first few years of a child's life. During this period, caregivers cannot rely on children to clearly communicate through words; instead, caregivers often must *infer* what children think and feel. These inferences critically depend on the adult's understanding of what the child is and is not capable of, and what scaffolding it would take for that child to become more capable. There is evidence of this across domains of development. For example, parent language use becomes more diverse and complex as children age and in concert with developing sophistication of the child's own language competence (Rowe, Pan, and Ayoub 2005; Huttenlocher et al. 2010), and parents interact differently depending on whether a child is crawling versus walking (Karasik, Tamis-Lemonda, and Adolph 2014) or holding versus looking at an object (West and Iverson 2017). Likewise, representations of children's mental lives, including their sensations, perceptions, emotions, cognitive abilities, executive function, and social skills have been shown to play a critical role in guiding adults' expectations of a child, their reactions to that child's actions, and the nature and development of their relationship with the child (Vreeswijk, Maas, and Bakel 2012; Feldman and Reznick 1996). Caregivers' capacity to form an accurate representation of their child's internal states and to use this representation to guide their caregiving behavior (so called "mind-mindedness") is positively associated with children's wellbeing, including attachment security, theory of mind, and ultimately, school readiness (Meins et al. 2012, 2013; Bernier, McMahon, and Perrier 2017).

Critical next steps in this line of research, then, will involve assessing which aspects of adults' beliefs and theories about the development of mental life facilitate the kinds of caregiving behaviors that are most appropriate in a given cultural setting, most in line with caregivers' own values and goals, or most beneficial for children according to experts. For example, in a recent study drawing on similar foundations to the studies reported here, parents who attributed greater mental capacities to young children in general expressed more interest in and curiosity about their own young child's mental states, and, in turn, reported engaging in more positive parenting behaviors (Salo et al. 2021; see also Laranjo, Bernier, and Meins 2008); could educating parents about infants' mental capacities and their rapid development spark increased curiosity in new parents, and would this have downstream consequences in their interactions with their children? An additional, related goal is to identify the gaps and misconceptions in these theories that might lead caregivers to over- or under-estimate a child's abilities and thus misinterpret the child's behaviors, miss opportunities to support the child's development, experience concern about their child's developmental progress, or even engage in neglectful or abusive behaviors toward the child. Identifying the antecedents of individual differences in these beliefs could be an especially important step for such clinically-focused applications. As is the case in many domains (Weisman and Markman 2017), interventions that leverage the power of intuitive theories to encourage positive and responsive caregiving behaviors hold great promise for creating meaningful and lasting behavioral changes in caregiver behavior, with important consequences for child wellbeing.

Methods

Methods, inclusion/exclusion criteria, and analyses marked as "preregistered" were preregistered on the Open Science Framework (OSF) website: (Study 1: https://osf.io/e6ajh/; Study 2: https://osf.io/j72dg; Study 3:

https://osf.io/xh8ce/). All studies were approved by the Stanford University Internal Review Board. For extended descriptions of methods and results, see Supplemental Material.

Study 1

Participants

301 US adults participated via Amazon Mechanical Turk (MTurk) in July–August 2018. Participants ranged in age from 19-45 years ($M = 31.37$ years, $sd = 5.75$ years) and included more men (59%) than women (41%; <1% of participants identified as some other gender or declined to disclose). Participants predominantly identified as White (66%; <15% identified as any other race/ethnicity, identified as more than one race/ethnicity, or declined to disclose). 51% of participants had obtained at least a Bachelor's degree. 44% of participants indicated that they were parents.

Materials and procedure

Participants completed three trials in which they assessed the mental lives of children at three target ages: birth, 9 months, and 5 years. On each trial, they were shown two representative photographs of children at the target age (labeled "newborns," "9-month-olds," or "5-year-olds"), and asked to answer the following question for 60 capacities: "To what extent is a [newborn/9-month-old/5-year-old] capable of [this capacity]?" Participants responded on a sliding scale from 0 (labeled "not at all capable") to 100 ("completely capable").

The 60 capacities included in Study 1 were drawn from several areas of previous research. Our goals in selecting items were to: (1) balance the representation of the conceptual organization underlying mental capacity attributions in general, as identified in previous work (Gray, Gray, and Wegner 2007; Weisman, Dweck, and Markman 2017b, 2017a, 2018; Malle 2019); (2) add items relevant to early development, as identified by existing measures of temperament and behavior in early life (Putnam, Gartstein, and Rothbart 2006; Rothbart 1978); and (3) assess the broadest range of mental capacities within financial and participant burden constraints, as identified by extensive discussions among the authors drawing on our own research and clinical experience with infants and young children. This process yielded a list of 60 capacities; see Figure 1, and see Supplemental Material for an item-by-item comparison of the capacities used here to those used in previous studies of mind perception. Capacities were presented in a random order.

In planning this series of studies, we selected 13 target ages based on the developmental milestone ages identified by the CDC (Centers for Disease Control and Prevention 2021) with the addition of the American Academy of Pediatrics' recommendations for pediatrician visits before 2 months (American Academy of Pediatrics 2018): birth, 4 days, 1 month, 2 months, 4 months, 6 months, 9 months, 12 months, 18 months, 2 years, 3 years, 4 years, and 5 years. We limited Study 1 to just the youngest, median, and oldest target ages—presented to participants as "newborns," "9-month-olds" and "5-year-olds"—in order to maximize the number of capacities included in the study without over-burdening participants. Target ages were presented in chronological order, with participants first assessing all 60 capacities for newborns, then 9-month-old infants, and finally 5-year-old children.

Study 2

Participants

304 US adults participated via MTurk in August 2018. Eligibility requirements were identical to Study 1. Participants ranged in age from 19-45 years ($M = 32.14$ years, $sd = 6.32$ years) and included roughly equal numbers of men (51%) and women (49%). Participants predominantly identified as White (75%; <11% identified as any other race/ethnicity, identified as more than one race/ethnicity, or declined to disclose). 50% of participants had obtained at least a Bachelor's degree. 41% of participants indicated that they were parents.

Materials and procedure

Participants completed 13 trials in which they assessed the mental lives of children at 13 target ages: birth, 4 days, 1 month, 2 months, 4 months, 6 months, 9 months, 12 months, 18 months, 2 years, 3 years, 4 years, and 5 years. On each trial, they were shown two representative photographs of children at the target age, and asked to answer the following question for 20 capacities: "To what extent is a [newborn/4-day-old/etc.] capable of [this capacity]?" As in Study 1, participants responded on a sliding scale from 0 (labeled "not at all capable") to 100 ("completely capable").

In order to ask participants to assess a more fine-grained array of target ages without undue participant burden, we limited our list of capacities to 20 of the 60 capacities used in Study 1. To identify this list, we drew on the results of Study 1, selecting 5 items for each of the 4 factors identified there. For each factor, we aimed to select items that loaded strongly on that factor, did not cross-load strongly on other factors, were sufficiently distinguishable from each other in meaning, and captured our qualitative understanding of the latent construct that each factor corresponded to. To represent *bodily sensations*, we chose the items "getting hungry," "feeling pain," "feeling tired," "feeling physically uncomfortable," and "hearing sounds." To represent *negative affect*, we chose the items "feeling distressed," "feeling lonely," "feeling frustrated," "feeling helpless," and "feeling overwhelmed." To represent *social connection*, we chose the items "feeling excited," "finding something funny," "loving somebody," "learning from other people," and "feeling happy." Finally, to represent *cognition and control*, we chose the items "planning," "having self-control," "reasoning about things," "controlling their emotions," and "telling right from wrong." Capacities were presented in a random order.

The target ages for this study were based on the developmental milestone ages described in Study 1. Target ages were presented in chronological order, with participants first assessing all 20 capacities for newborns, then 4-day-old infants, and so forth.

Study 3

Participants

301 US adults participated via MTurk in April 2019. Eligibility requirements were identical to Studies 1-2. Participants ranged in age from 18-45 years ($M = 31.67$ years, $sd = 5.78$ years) and included roughly equal numbers of men (53%) and women (47%). Participants predominantly identified as White (67%; <12% identified as any other race/ethnicity, identified as more than one race/ethnicity, or declined to disclose). 53% of participants had obtained at least a Bachelor's degree. 34% of participants indicated that they were parents.

Materials and procedure

Participants completed eight trials, in which they assessed each of the eight capacities in turn; the order of capacities was randomized across participants. On each trial, participant assessed children at all 13 target ages used in Study 2 in a fixed order from youngest to oldest. Each age was presented along with a representative pair of photographs (also used in Studies 1 and 2), and participants were asked to answer the following question: "To what extent is a [newborn/4-day-old/1-month-old/etc.] capable of [this capacity]?" Participants responded on a sliding scale from 0 (labeled "not at all capable") to 100 ("completely capable").

On each trial, participants completed a set of questions about the possible mechanisms that drive development for the capacity in question. First, they were asked, "In your opinion, how important is each of the following factors in the development of children's capacity for [capacity]?" They provided independent ratings on a Likert-type scale from 0 (labeled "not at all important") to 6 ("extremely important"), for 10 developmental mechanisms presented in a fixed order; see Results for all items. Participants were also asked to choose among these 10 mechanisms (or to write in another mechanism) to answer the question, "If you had to

choose just one, which of the following factors is the most important in the development of capacities for [capacity]?"

Because Study 3 included additional questions probing participants' theories of developmental mechanisms, we reduced the set of mental capacities from 20 in Study 2 to 8 in the current study to maintain an appropriate level of participant burden. We chose "controlling their emotions" and "reasoning about things" to represent the domain of *cognition and control*; "getting hungry" and "feeling pain" to represent the domain of *bodily sensations*; "learning from other people" and "feeling happy" to represent the domain of *social connection*; and "feeling distressed" and "feeling helpless" to represent the domain of *negative affect*. Capacities were presented in a random order for each participant.

The 13 target ages for this study were identical to Study 2, with the exception that we added the parenthetical phrase "(at birth)" when referring to newborns.

References

American Academy of Pediatrics. 2018. "AAP Schedule of Well-Child Care Visits." 2018. https://www.healthychildren.org/English/family-life/health-management/Pages/Well-Child-Care-A-Check-Up-for-Success.aspx.

Berent, Iris, Lisa Feldman Barrett, and Melanie Platt. 2020. "Essentialist Biases in Reasoning about Emotions." *Frontiers in Psychology* 11: 562666. https://doi.org/10.3389/fpsyg.2020.562666.

Berent, Iris, Melanie Platt, and Gwendolyn M. Sandoboe. in press. "Empiricism Is Natural: It Arises from the Collision of Dualism and Essentialism." *Oxford Studies of Experimental Philosophy*, in press. https://web.northeastern.edu/berentlab/wp-content/uploads/2020/10/origins-of-antinativism18.pdf.

———. 2019. "People's Intuitions about Innateness." *Open Mind* 3: 101–14. https://doi.org/10.1162/opmi_a_00029.

Bernier, A., C. A. McMahon, and R. Perrier. 2017. "Maternal Mind-Mindedness and Children's School Readiness: A Longitudinal Study of Developmental Processes." *Developmental Psychology* 53 (2): 210–21. https://doi.org/10.1037/dev0000225.

Centers for Disease Control and Prevention. 2021. "CDC's Developmental Milestones." 2021. https://www.cdc.gov/ncbddd/actearly/milestones/index.html.

Feldman, Ruth, and J. Steven Reznick. 1996. "Maternal Perception of Infant Intentionality at 4 and 8 Months." *Infant Behavior and Development* 19 (4): 483–96. https://doi.org/10.1016/S0163-6383(96)90008-9.

Gerstenberg, Tobias, and Joshua B Tenenbaum. 2017. "Intuitive Theories." In *The Oxford Handbook of Causal Reasoning*, edited by Michael Waldmann. Oxford Library of Psychology. New York, NY: Oxford University Press.

Gopnik, Alison, and Henry M. Wellman. 1994. "The Theory Theory." In *Mapping the Mind*, edited by Lawrence A. Hirschfeld and Susan A. Gelman, First, 257–93. Cambridge University Press. https://doi.org/10.1017/CBO9780511752902.011.

Gray, Heather M., Kurt Gray, and Daniel M. Wegner. 2007. "Dimensions of Mind Perception." *Science* 315 (5812): 619. https://doi.org/10.1126/science.1134475.

Haimovitz, Kyla, and Carol S. Dweck. 2016. "What Predicts Children's Fixed and Growth Intelligence Mind-Sets? Not Their Parents' Views of Intelligence but Their Parents' Views of Failure." *Psychological Science* 27 (6): 859–69. https://doi.org/10.1177/0956797616639727.

Hembacher, Emily, and Michael C. Frank. 2020. "The Early Parenting Attitudes Questionnaire: Measuring Intuitive Theories of Parenting and Child Development." *Collabra: Psychology* 6 (1): 1–11. https://doi.org/10.1525/collabra.190.

Huttenlocher, J., H. Waterfall, M. Vasilyeva, J. Vevea, and L. V. Hedges. 2010. "Sources of Variability in Children's Language Growth." *Cognitive Psychology* 61: 345–65. https://doi.org/10.1016/j.cogpsych.2010.08.002.

Karasik, L. B., C. S. Tamis-Lemonda, and Karen E. Adolph. 2014. "Crawling and Walking Infants Elicit Different Verbal Responses from Mothers." *Developmental Science* 17 (3): 388–95. https://doi.org/10.1111/desc.12129.

Laranjo, J., A. Bernier, and E. Meins. 2008. "Associations Between Maternal Mind-Mindedness and Infant Attachment Security: Investigating the Mediating Role of Maternal Sensitivity." *Infant Behavior and Development* 31 (4): 688–95. https://doi.org/10.1016/j.infbeh.2008.04.008.

Malle, Bertram F. 2019. "How Many Dimensions of Mind Perception Really Are There." In *Proceedings of the 41st Annual Meeting of the Cognitive Science Society*, edited by A. K. Goel, C. M. Seifert, and C. Freksa, 2268–74.

Meins, Elizabeth, Charles Fernyhough, Bronia Arnott, Susan R. Leekam, and Marc de Rosnay. 2013. "Mind-Mindedness and Theory of Mind: Mediating Roles of Language and Perspectival Symbolic Play." *Child Development* 84 (5): 1777–90. https://doi.org/10.1111/cdev.12061.

Meins, Elizabeth, Charles Fernyhough, Marc de Rosnay, Bronia Arnott, Susan R. Leekam, and Michelle Turner. 2012. "Mind-Mindedness as a Multidimensional Construct: Appropriate and Nonattuned Mind-Related Comments Independently Predict Infant–Mother Attachment in a Socially Diverse Sample." *Infancy* 17 (4): 393–415. https://doi.org/10.1111/j.1532-7078.2011.00087.x.

Mukhopadhyay, A., and C. W. M. Yeung. 2010. "Building Character: Effects of Lay Theories of Self-Control on the Selection of Products for Children." *Journal of Marketing Research* 47 (2): 240–50. https://doi.org/10.1509/jmkr.47.2.240.

Putnam, S. P., M. A. Gartstein, and M. K. Rothbart. 2006. "Measurement of Fine Grained Aspect of Toddler Temperament: The Early Childhood Behavior Questionnaire." *Infant Behavior and Development* 29 (3): 386–401. https://doi.org/10.1016/j.infbeh.2006.01.004.

Rothbart, M. K. 1978. "Infant Behaviour Questionnaire (IBQ)."

Rowe, Meredith L., Barbara Alexander Pan, and Catherine Ayoub. 2005. "Predictors of Variation in Maternal Talk to Children: A Longitudinal Study of Low-Income Families." *Parenting* 5 (3): 259–83. https://doi.org/10.1207/s15327922par0503_3.

Salo, Virginia C., Mia C. Letterie, Kara Weisman, Lucy S. King, and Kathryn L. Humphreys. 2021. "Parents' Perceptions of Young Children's Minds Are Associated with Their Interest in and Behavior Toward Their Own Child." https://doi.org/10.31219/osf.io/8uzxn.

Vreeswijk, C. M. J. M., A. J. B. M. Maas, and H. J. A. van Bakel. 2012. "Parental Representations: A Systematic Review of the Working Model of the Child Interview." *Infant Mental Health Journal* 33 (3): 314–28. https://doi.org/10.1002/imhj.20337.

Wang, & Feigenson, J. 2019. "Is Empiricism Innate? Preference for Nurture over Nature in People's Beliefs about the Origins of Human Knowledge." *Open Mind* 3: 89–100. https://doi.org/10.1162/opmi_a_00028.

Weisman, Kara, Carol S. Dweck, and Ellen M. Markman. 2017a. "Children's Intuitions about the Structure of Mental Life." In *Proceedings of the 39th Annual Meeting of the Cognitive Science Society*, 1333–38.

———. 2017b. "Rethinking People's Conceptions of Mental Life." *Proceedings of the National Academy of Sciences* 114 (43): 11374–79. https://doi.org/10.1073/pnas.1704347114.

———. 2018. "Folk Philosophy of Mind: Changes in Conceptual Structure Between 4-9y of Age." In *Proceedings of the 40th Annual Meeting of the Cognitive Science Society*, 1163–68.

Weisman, Kara, Cristine H. Legare, Rachel E. Smith, Vivian A. Dzokoto, Felicity Aulino, Emily K. Ng, John C. Dulin, Nicole Ross-Zehnder, Joshua D. Brahinsky, and Tanya Marie Luhrmann. 2021. "Similarities and Differences in Concepts of Mental Life Among Adults and Children in Five Cultures." *Nature Human Behavior*.

Weisman, Kara, and Ellen M. Markman. 2017. "Theory-Based Explanation as Intervention." *Psychonomic Bulletin & Review* 24 (5): 1555–62. https://doi.org/10.3758/s13423-016-1207-2.

Wellman, Henry M., and Susan A. Gelman. 1992. "Cognitive Development: Foundational Theories of Core Domains." *Annual Review of Psychology* 43 (1): 337–75. https://doi.org/10.1146/annurev.ps.43.020192.002005.

West, K. L., and J. M. Iverson. 2017. "Language Learning Is Hands-on: Exploring Links Between Infants' Object Manipulation and Verbal Input." *Cognitive Development* 43 (1): 190–200. https://doi.org/10.1016/J.COGDEV.2017.05.004.