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Review

Learning with certainty in childhood

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Learners use certainty to guide learning. They maintain existing beliefs when certain, but seek further information when they feel uninformed. Here, we review developmental evidence that this metacognitive strategy does not require reportable processing. Uncertainty prompts nonverbal human infants and nonhuman animals to engage in strategies like seeking help, searching for additional information, or opting out. Certainty directs children's attention and active learning strategies and provides a common metric for comparing and integrating conflicting beliefs across people. We conclude that certainty is a continuous, domain-general signal of belief quality even early in life.

Highlights

Intelligent organisms use uncertainty to guide them towards material that is useful for learning and integrate observations with existing beliefs.

Human adults' verbal reports of certainty predict information-seeking and belief change, which makes clear that certainty facilitates learning but leaves ambiguous whether a reportable representation is required.

Recent work that used novel behavioral measures of certainty demonstrates that nonverbal infants and nonhuman animals represent their certainty as a graded and domain-neutral signal.

Uncertainty guides children's information seeking and acts as a common metric to compare and integrate multiple information sources across diverse cognitive domains.

Using certainty to guide learning is thus an early emerging phenomenon rather than an advanced one.

Leveraging uncertainty to make sense of the world

Learners direct their own learning by strategically seeking out information that is unknown or surprising [1–3]. Adults prioritize studying hard exam questions [4], children ask for help on difficult tasks [5,6], and infants explore objects that violate their expectations [7,8]. The ability to differentiate what is known or expected from what is unknown or unexpected enables these behaviors. This implies that learners leverage their **certainty** (see Glossary; and its inverse, **uncertainty**) as a metric for what they know. This interpretation is endorsed for adult human learners [9], yet is resisted in childhood, infancy, and nonhuman populations based on beliefs that children are not **metacognitive** and that certainty requires sophisticated reasoning [10,11]. Here, we present evidence that this resistance is unwarranted. We outline the empirical case that certainty is a valuable learning signal even for very young children.

The first empirical investigations on certainty in psychology used paradigms that required verbal responses and thus measured only reportable mental states [10,12,13]. Children appear unaware of their own knowledge when asked using these methods, reporting that they had always known a fact that they just learned [14]. Subsequent work revealed that children can report more accurately on their certainty when asked in appropriate ways. Three-year-old children appropriately report lower confidence following inaccuracies when given a simple response scale that includes pictures, as do 20-month-old children when they convey confidence through a request for help [15,16]. This evidence suggests young children are more metacognitively sophisticated than previously credited.

Certainty also need not be reportable to affect learning. Nonverbal human infants and nonhuman animals use certainty to guide their behavior in ways that would benefit learning [17–19] (for reviews, see [20,21], for critique, see [22]). Agents persist on tasks longer when they are accurate or when the task is easy, and opt out of tasks or seek external guidance when they are inaccurate or the task is hard [6,16,19,23]. Agents in these studies are not given external feedback about their accuracy or task difficulty, so they must rely on representations of certainty as a proxy metric of their knowledge and abilities.

We adopt this functional perspective to demonstrate that certainty guides children's learning. We outline the known properties of children's reasoning about certainty and highlight the implications

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each property has for learning. We then summarize the two broad ways that certainty impacts learning: by directing information search and by facilitating comparison.

Properties of certainty

Identifying signature properties of certainty representations helps us understand how certainty is useful to learners across development. We overview four such properties. For each, we discuss the available evidence for these properties in childhood and the resulting predictions for children's learning.

We are certain about mental activities

Certainty takes one's own mental processes as its object, unlike mental representations that refer to a property of the external world [24]. You may activate the mental representation for the concept BLUEJAY by matching the light patterns reflecting off an object to your stored concept of BLUEJAY. That representation is about the world – the actual object's identity – not about your own mental content or process. A certainty representation in this context could integrate uncertainty that you correctly categorized the object as a bluejay and not a bluebird (uncertainty about your categorization), or uncertainty that you know what a bluejay looks like (uncertainty in your conceptual knowledge). This property also distinguishes certainty, in principle, from objective probability judgments (e.g., there is a 2 in 3 chance of drawing a blue marble due to the composition of marbles in the bag). Objective probability is a property of the world, not necessarily our mental representation of it. Shared cognitive resources for probabilities and certainty remain an open empirical question.

Since certainty is always associated with a mental representation, certainty is influenced by two broad sources. First, uncertainty is inherent in forming any mental representation. Our imperfect visual systems interpret light patterns to generate the visual representation of a bird, which is then matched to our working concept of BLUEJAY. Uncertainty is built into the mental representation (e.g., there would be more uncertainty if our vision was blurry) and can be detected in the firing patterns of sensory neurons [25,26]. Second, uncertainty is introduced when making a confidence judgment. We might integrate cues like decision latency that correlate with inaccuracy or compute the reliability of our decision [27]. Low certainty about whether a bluejay flew by you could thus stem from the way you represent external contextual ambiguity (e.g., uncertainty because the bird moved fast and bluejays and bluebirds are perceptually similar), from additional information used to make your internal confidence judgment (e.g., uncertainty from a past experience of mistaking a piece of paper for a bluejay), or from a combination thereof (for more thorough discussions of these influences, see [26–28]).

Both sources of certainty impact learning. We use uncertainty inherent in our mental representations to prioritize information from more reliable senses [29] and even infants strategically allocate attention to visual patterns that are intermediately predictable over too-predictable or too-unpredictable patterns [3]. We use uncertainty unique to our confidence judgments to direct study efforts toward items we feel are unknown [4] or sometimes elect not to seek information about a belief [30].

Presently, most studies of certainty and learning in childhood do not differentiate the influence of these sources. It is empirically difficult to separate the influence of uncertainty inherent to the mental representation from the influence of the uncertainty introduced when making a confidence judgment as these are often highly correlated [31,32]. Current approaches involve administering hundreds of trials to facilitate statistical corrections (e.g., metacognitive efficiency in the meta-d' model) [32], which are not scalable to populations with short attention spans. Further, face-

Glossary

Bayesian learning: a principled mechanism for combining prior beliefs with new evidence on the basis of their respective uncertainty distributions.
Calibrate/calibration: how well the reports or decisions align with the expected and/or optimal reports or decisions. A perfectly calibrated sense of certainty based on accuracy would report high certainty whenever accurate and low certainty whenever inaccurate.
Certainty/uncertainty: the signal about the quality, in terms of accuracy or reliability, of our own cognitive states or processes.
Confirmation bias: the tendency for people to prioritize evidence that agrees with their existing views.
Criterion: the threshold between reporting or decision options on a continuum.
Domain-general: the same properties irrespective of the cognitive domain.
Metacognitive: the mind's ability to represent and evaluate other cognitive states or processes.
Sensitivity: the ability to tell apart points on a continuum. Better sensitivity means that you can discriminate between many subtle differences.

valid measures of subjective experiences like introspective reports assume subjects are honest and able to communicate their certainty. We need to consider a broader range of methods than what is used with educated adults as we look for certainty unique to internal confidence judgments in the learning process beyond adulthood [16,17,33] (for a recent overview, see [20]). By using these methods in tandem with methods that manipulate or measure uncertainty inherent in the mental representation, we can uncover any unique mechanisms, affordances, and/or constraints for learning that stem from each source of certainty.

Although these two broad sources of certainty often align, a decider's internal confidence may be miscalibrated to their accuracy in many cases, even though accuracy is also influenced by the uncertainty inherent in the mental representation. For example, in one study [34], learners in a novel concept learning task became more confident than their subsequent accuracy would justify when they made a series of lucky guesses about whether a shape fit into a novel latent category. A string of lucky guesses could thus prompt a learner to become so confident that they disengage from collecting the additional data required to correct their misconception.

As a quick note, these sources are sometimes distinguished as two different types of certainty given the likely computational differences (e.g., objective and subjective certainty, as in [35], or certainty and confidence as in [26]). Our use of certainty in this paper encompasses both sources because they have the same broad functions for the learner (see 'How certainty guides learning'), and there is presently limited developmental evidence to disentangle the mechanisms of their influence on learning.

Certainty is a signal about belief quality

We expect high certainty judgments to be accurate, and we expect low certainty judgments to be unreliable [26,36]. Introspective reports reflect these expectations ('I am sure I got it right', 'I feel 80% likely that I know their name'), as do strategic behaviors (persisting in anticipation of a reward, seeking help when torn between two options [20,21,37]. Researchers can empirically verify certainty judgments by comparing a subject's certainty report or behavior with the subject's objective accuracy on a target activity. The objective accuracy tells us what the subjective representation of certainty should be if certainty was appropriately encoding the chances that they will be correct. Showing this predicted link, 3–5-year-old children reported higher certainty on a 3-point scale when they correctly recalled whether they had seen a picture [15,33]. Similarly, primates opted out when likely to be inaccurate, resulting in higher accuracy on a memory test when opting out was permitted [38].

Certainty isolates the subjective quality of a judgment from other metacognitive signals about the origin of that judgment and the optimal resulting actions. The experience of high certainty does not tell you why that judgment feels right or how you came to know something [39]. Learners must use a suite of metacognitive skills to gain the full picture of their knowledge, rather than certainty alone. The experience of high certainty also does not tell you how to optimally use that signal. Learners need decision-making strategies contingent on different levels of certainty for it to be a useful signal [24,40]. These additional skills and strategies may develop independently from a sense of certainty but impose important affordances or constraints on how certainty is used.

Certainty is a continuum

We can experience feeling certain and uncertain, but also extremely certain, somewhat certain, and many degrees in between. These distinctions hold meaning. Adults' confidence judgments on continuous gradients (e.g., 0–100% or Likert scales) increased as accuracy increased and trial difficulty decreased [12,24,41]. Rats' waiting time for a reward increased and neural firing in the orbito-frontal cortex decreased as rats were presented with easier odor categorizations [18]. This graded pattern also appears in behavioral measures that use a simplified gradient or even a binary response for younger subjects. The proportion of high certainty behaviors or responses increases as trial difficulty decreases [6,15–17,33,42]. Infants' likelihood of engaging with material changes continuously as their degree of certainty and surprise about that material change through learning [3,43,44].

Another demonstration of continuity comes from forced-choice measures of certainty. Subjects compare their certainty between two trials that vary in how similar the states of certainty are (e.g., from 'very sure' against 'not sure' to 'extremely sure' against 'very sure', indexed both by accuracy and trial difficulty [31]). If certainty were discrete rather than continuous, subjects should confuse all high certainty cases together and all low certainty cases together. Yet, both adults and children successfully identify items with higher certainty for a range of certainty contrasts [45–48].

Certainty as a continuum necessitates two skills for learners. First, learners need to be sensitive to differences in states of certainty. Some learners can only differentiate extreme contrasts, while others can differentiate closer contrasts [45]. One of the notable developments in certainty reasoning during childhood is the fine-tuning of **sensitivity** to certainty; older children differentiate finer degrees of certainty [45]. Second, learners must **calibrate** their certainty appropriately to the available response options. Learners deciding whether to ask for help must categorize the continuous certainty signal into either asking for help or refraining, split by a **criterion**: the threshold between decision options. If the criterion is misplaced, the learner may ask for help more or less often than needed. Calibrating certainty to the available response options also develops in childhood [42,49,50]. Younger children trend towards overconfidence, but calibration improves as children get older [42,49,51].

These changes in both sensitivity and calibration suggest that certainty emerges as a noisy continuum, like other perceptual continua. As a parallel, infants are sensitive to differences in numerical magnitude at birth, but only when there is a large ratio between the numbers (e.g., 1 vs 3, [52]). Sensitivity to number improves such that 6-month-old infants can discriminate 1 from 2 [53], 9-month-old children can discriminate 2 from 3 [54], and adults can discriminate 10 from 11 [55]. Children also learn to calibrate those intuitive representations of number with number words [56]. The emerging evidence of certainty as a continuum suggests a similar developmental trajectory. A young learner's inability to detect subtle differences in certainty states may therefore reflect an imprecise sense of certainty that can only discriminate extreme contrasts rather than the absence of a sense of certainty [45]. Like intuitions about number, certainty may exist as an imprecise sense from very early in development, with critical fine-tuning occurring in early childhood. It is still an open empirical question why certainty sensitivity and calibration improve, and could be related to natural maturation, changes in expertise, or the development of related skills (e.g., representing alternative possibilities; [57]).

Certainty holds meaning across domains

We can feel certain about the presence of a memory, the estimate of a surface area, the value of a possession, and even recursively about the experience of certainty. One explanation for this breadth is a single cognitive resource that reasons about certainty for all decisions (akin to 'g' for intelligence [58]). Correlated individual differences are used to support this explanation, including correlations in the sensitivity of certainty judgments across numerical reasoning, semantic memory, and executive function in adulthood [58,59]. However, there is limited causal evidence of modified certainty judgments transferring from one domain to another. Adults in one training study had better calibrated certainty in a recognition memory task after receiving certainty calibration training on a perceptual brightness task [60,61], but this has failed to replicate when fixing methodological confounds [62].

The few studies with children also show mixed results. Individual differences in sensitivity to certainty correlate across domains by 4–8 years of age, with stronger evidence of transfer after 6 years [45,61]. Children aged 6–9 years who were more sensitive to certainty about number comparisons (e.g., 'which group has more dots?') were also more sensitive to certainty about emotion comparisons (e.g., 'which face is happier?') and area comparisons (e.g., 'which shape is bigger?') [46] (see also [63] for correlations in arithmetic and spelling certainty). However, individual differences in those same domains are uncorrelated at younger ages [42,64]. Children aged 4–7 years who were more sensitive to certainty about number comparisons were more sensitive to certainty about area comparisons but not emotion comparisons [42,64]. Thus, any **domain-general** mechanism for reasoning about certainty likely emerges during childhood rather than being an inherent property of reasoning about certainty.

With maturation, certainty becomes a common scale for comparing information that uses distinct units. By 6 years old, children can compare feelings of certainty between emotion and number judgments – two decision domains that otherwise do not share common units (one cannot be more 'three' than 'happy', for instance) [65]. This builds upon growing evidence that adults can flexibly exchange certainty judgments between different visual decisions (e.g., matching either the orientation or the frequency of a grating) and between different sensory modalities (e.g., vision and audition) [48,66,67]. Certainty is therefore not constrained to the domain it references (e.g., emotion or number), or else can easily be converted into a common format by school-aged children. It is currently unknown whether this applies to younger children.

These findings pose two implications for learners. First, training interventions that target certainty may remain localized to the domain of training (e.g., specific to math certainty) until later childhood or adulthood, given the lack of correlated individual differences in younger children. Second, certainty is comparable across individual cognitive domains by at least 6 years of age. It acts as a common metric to compare the quality of two judgments from unrelated domains or between people. A learner could compare their certainty in what they see against their certainty in what they hear to evaluate which source is more trustworthy. This account naturally aligns with theories of **Bayesian learning** and sensory integration in which the uncertainty of competing options are evaluated and combined across traditional cognitive boundaries [29,68].

How certainty guides learning

Certainty representations provide learners with a common metric for determining the quality of their beliefs. Certainty can be used to identify information yet to be learned or to compare the relative merits of two pieces of information. Emerging evidence demonstrates these two functions early in human development and across species, consistent with certainty's role as a fundamental learning signal. We elaborate on these two functions here.

Certainty directs information search

Certainty allows us to identify and then attend to things that we do not yet know. If uncertain, we can seek information to increase our knowledge; if certain, we can devote our attention to more fruitful pursuits. Certainty directs attention in developmental and comparative populations [6,16,19,69]. For instance, 3-year-old children, chimpanzees, and rhesus monkeys checked for an item inside a tube less frequently if they witnessed the experimenter hide the item than if the hiding event was blocked from view [19,69]. Several other species seek information when experiencing uncertainty (e.g., dogs [70], ravens [71], bees [72], for review see [73]), and this behavior extends beyond finding hidden objects to learning new words and building intuitive theories [74,75] (Box 1).

Learners are most attentive to intermediate degrees of the certainty continuum. Infants, older children, and even rhesus macaques preferentially attended to sequential events of intermediate surprisal values rather than those that were too predictable or overly unexpected [3,76–78] (Box 2). These findings align with classic developmental theories including the zone of proximal development and 'theory' theory, in which children are driven to attend to information just beyond their current capabilities which in turn optimizes their learning [1,79,80].

Information can also be acquired from other social agents through imitation or soliciting help, reflected in the species-general social learning strategy 'copy when uncertain' [81]. Rats preferred the diet choices of demonstrator rats when facing uncertainty about the source of a foodborne illness than when given disambiguating evidence about the source [82]. Twenty-month-old infants also referenced a caregiver more often when they made incorrect guesses on a memory test and when recall was more difficult due to longer delays from encoding to test [16]. Certainty thus directs information search early in development and across species in both social and asocial contexts.

The optimal use of certainty requires that the criterion is appropriately placed so that learners seek information only when it would truly benefit them. Consider a child deciding whether to ask for help from a teacher. That child could use a very low criterion – only asking for help when utterly uncertain – but they would potentially miss out on guidance for mildly uncertain items. A child who instead asks for help on almost everything may monopolize a teacher's time or even hinder learning if the teacher takes over [83].

Well-calibrated criterion-setting predicts success on educational measures. Fifth-graders with better-calibrated certainty reports about math questions performed better on a math assessment and showed larger gains in math ability by grade 8 [84,85]. This effect appears to be largely driven by individual variability in calibration, rather than sensitivity to certainty. Variability in 4–6-year-old children's metacognitive sensitivity did not predict their math performance when individual differences in calibration were removed by using a forced-choice paradigm [86]. We can reason that

Box 1. Certainty directs word learning

Learning a language is a difficult feat, but one that most human toddlers accomplish in just a few years. Toddlers learn words rapidly by using a sophisticated suite of language-learning biases including the mutual exclusivity bias: the assumption one object is unlikely to have two labels [94]. Toddlers attribute a novel label to a novel object if there is a familiar object present, knowing that the familiar object already has a familiar label [94] (for a meta-analysis of this effect, see [95]). This inference requires that learners recognize, at least implicitly, that they are certain about the known object's label.

The strength of word knowledge – what certainty encodes – impacts the use of the mutual exclusivity bias to learn new words. Children are more likely to attribute the novel word to the novel object when they have strong knowledge of the competitor object's label (e.g., producing its label correctly compared to understanding but not correctly producing the label) [96]. Reasoning about certainty helps drive this inference. The mutual exclusivity effect was strongest in adults when they reported high certainty in the familiar competitor [97]. Preschoolers who correctly categorized items they knew and items they did not know also showed a stronger mutual exclusivity bias, independent of age and vocabulary size [98–100]. Certainty about word knowledge helps both young and older learners identify the likely referents of new words.

Word learning in childhood also reflects the continuous nature of certainty. The degree of ambiguity about a word modulated children's information search from a computer or a caregiver [5,74]. Children sought information least often for unambiguous evidence or a known word, and most often when given highly ambiguous evidence (e.g., there are two equally likely candidates). Mildly ambiguous evidence that could be disambiguated through the mutual exclusivity principle led to intermediate information-seeking in children aged 2–8 years [5,74].

Box 2. Certainty motivates curiosity

Curiosity is a drive to reduce uncertainty [40]. Infants' attention and exploration offer an early signal of their curiosity [101]. For instance, infants who viewed a train roll down a hill and appear to pass through a solid wall looked at the event longer and explored the solidity of the train by hitting it against their highchair [8]. These behaviors were believed to be geared toward reducing uncertainty: the infants did not look longer or explore the object if an explanation for a surprising event was given (e.g., the wall had a hole in it) [102].

Curiosity is also linked to learning. Infants were more likely to learn an association between a hidden property (e.g., squeaking) and an object that appeared to pass through a solid wall than an object that did not [8]. Preschool children were more likely to learn the label for an object that appeared to teleport rather than one that visibly moved locations [103]. Children and adolescents were also more likely to remember trivia facts that they expressed curiosity about [104]. Part of the link between curiosity and learning may result from learners considering the expected learning alongside their uncertainty [105–107]. Uncertainty can be evoked for anything unpredictable or unknown, but learners as young as 7 months seem to experience certainty judiciously for material that is possible for them to learn [3,77,78].

The definition of uncertainty within the curiosity literature typically revolves around the unpredictability of the environment, rather than the quality of one's own beliefs. These two are undeniably linked (as discussed in ' We are certain about mental activities' in the main text). If your environment is unpredictable, then any beliefs you generate about that environment should be held with less certainty. The degree to which subjects' curiosity reflects their own psychological experience remains an open question for future research.

learners need some sensitivity to certainty to discriminate extreme contrasts in high and low certainty because certainty calibration relates to learning. However, it appears that the larger gains come from learning to optimally calibrate their certainty to the available response options rather than precisely discerning nearby states of certainty.

The definition of optimal calibration depends in part on the availability and constraints on available information sources, making it likely to be malleable to feedback. Adults' reports of certainty are heavily influenced by feedback about decision accuracy on previous trials [34], and by feedback about criterion-setting [60,87]. In childhood as well, a study with kindergarteners found that providing feedback on both task performance and criterion-setting improved the calibration of children's certainty judgments to their performance [50]. Targeted feedback about certainty calibration is therefore a fruitful avenue for training interventions throughout the lifespan.

Certainty acts as a common metric to compare information

Learners must also identify truth amid conflicting information. We need to choose between two answers on multiple-choice tests, or discern whether a news story is true given what we already know. Certainty is valuable here as a common metric of the quality of our beliefs to facilitate comparison between competing options.

Adults and children use certainty to differentiate competing options to meet their goals [46,47,88]. Children 5 years and older strategically opted to answer questions with a high likelihood of success (as indexed both by children's accuracy as well as the difficulty of the questions) when rewards were provided for correct responses [46,88]. Children by 4–5 years old also integrate certainty with early social understanding by assigning high certainty items to collaborators with less skill and offering to help others faced with difficult tasks [89,90]. Theories of achievement motivation also presuppose that children differentiate easy from difficult items, preferring easy items when driven to demonstrate competence and preferring challenging items when driven to build new skills [91].

Comparing the quality of information is also a critical component of updating your beliefs. It is rational to update a belief if presented with higher certainty evidence of a competing belief, a finding consistently documented under the frame of Bayesian learning [2] (Box 3). The interchangeability of

Box 3. Certainty facilitates social belief revision

Social groups allow us to divide labor, but that also mean that we will face disagreements about what is true due to differing experiences. We need ways to navigate conflicting inputs, and certainty is one tool that facilitates social decision-making and belief revision [108]. Information communicated with high certainty should generally be more reliable than information communicated with low certainty, given that certainty generally predicts accuracy [109]. Rational decision-makers can therefore weigh each piece of information by its respective certainty to form an improved, integrated estimate. This pattern is consistent with theories of Bayesian cue combination in belief revision [110], and is reflected in adults' decision-making [108].

Certainty is also a critical component of children's belief revision in social contexts. Preschool children generally trusted an adult who indicated that a prize fell into a counterintuitive hidden location, but were skeptical when they could be certain of its presence in a different location [111]. Children also trusted collaborators more when their own beliefs were founded on probabilistic rather than deterministic evidence, and when the collaborator communicated high confidence [112,113].

An important caveat is that belief revision is not always perfectly rational. Adults and children are unlikely to change their beliefs if held with high confidence, even when conflicting evidence is also presented with high confidence [30,114,115]. This bias can be problematic when a learner is overconfident and unwilling to engage with the conflicting evidence. However, a **confirmation bias** can improve decision-making when the subject has well-calibrated metacognition by reducing susceptibility to false high-confidence claims, thereby protecting a learner from falling for another's overconfident claim [116]. Developmental and comparative investigations into the constraints learners apply will reveal whether these biases are inherent to the way certainty is used or learned from experience with untrustworthy claims.

certainty representations across domains is particularly useful here because it allows a decision maker to compare the reliability of information from distinct sources [48,65]. When deciding which of two groups is more socially dominant for instance, decision makers might integrate their certainty in the physical size difference to their certainty in the numerical size difference between groups [92].

Concluding remarks

Certainty is a valuable, early emerging signal for learning. In contrast to accounts that reasoning about certainty is a sophisticated high-level cognitive process restricted to humans well into ontogeny [10,93], research with nonverbal infants and nonhuman primates suggests certainty is available broadly throughout the lifespan and our evolutionary history as a foundational signal about the quality of mental processes and beliefs. Knowledge of how certainty influences learning in inexperienced populations such as children reveals how reasoning about beliefs becomes more complex over time (see Outstanding questions). Additionally, formal theories of how certainty is represented are foundational not only for optimizing learning in humans, but also for developing artificially intelligent agents capable of more autonomous learning.

Outstanding questions

How does a certainty representation form? What sources are used (e.g., direct computations from sensory noise, feedback on past performance) and how does their influence change as children develop?

How alike are reasoning about certainty and objective probability?

Can learners be taught to leverage their certainty more effectively?

How can representations of certainty benefit artificial learning algorithms?

Does culture impact the way humans generate and use certainty?

How does certainty contribute to self-efficacy? Do people maintain a global sense of their own general certainty?

How does our own certainty influence how we interpret the certainty of others?

What consequences arise from imperfect certainty?

Does certainty influence learning differently in childhood relative to adulthood?

How does certainty interact with other early-emerging learning capacities?

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