BRILL

JOURNAL OF COGNITION AND CULTURE 21 (2021) 226–242

brill.com/jocc

Are Children Sensitive to What They Know?: An Insight from Yucatec Mayan Children

Sunae Kim | ORCID: 0000-0003-1237-2154
Department of Psychology, Health, and Professional Development, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK
Corresponding author
sunaekim2@gmail.com

Olivier Le Guen | ORCID: 0000-0001-7314-242X
Department of Linguistics, Center for Research and Higher Studies in Social Anthropology (CIESAS), Mexico City, Mexico
ompleguen@gmail.com

Beate Sodian
Department of Psychology, Faculty of Psychology and Education, Ludwig Maximilians University, Munich, Germany
sodian@psy.lmu.de

Joélle Proust | ORCID: 0000-0001-8466-0548
Department of Cognitive Science, Institut Jean-Nicod, École Normale Supérieure, Paris, France
Joelle.proust@gmail.com

Abstract

Metacognitive abilities are considered as a hallmark of advanced human cognition. Existing empirical studies have exclusively focused on populations from Western and industrialized societies. Little is known about young children's metacognitive abilities in other societal and cultural contexts. Here we tested 4-year-old Yucatec Mayan (a rural native population from Mexico) by adopting a metacognitive task in which children's explicit assessment of their own knowledge states about the hidden content of a container and their informing judgments (whether or not to inform an ignorant person about the hidden contents of a container) were assessed. Similar to previous studies, we found that Yucatec Mayan children overestimated their knowledge states in

 | DOI:10.1163/15685373-12340106

the explicit metacognitive task. However, in contrast with studies on Western children, we did not find the facilitating effect of the implicit informing task over the explicit task. These findings suggest that the early development of metacognition combines universal and culture-sensitive features.

Keywords

metacognition – Yucatec Maya – epistemic understanding – young children

1 Introduction

Human metacognitive abilities – the abilities through which one's own cognitive abilities are monitored and controlled – have fascinated scholars and philosophers like Aristotle or Descartes. Empirical studies of metacognition started exploring the forms and origins of metacognition only four decades ago (e.g., Flavell, 1979; Kuhn et al., 1988; Markman, 1979; Mitchell & Lacohee, 1991) and, to date, studies have exclusively concerned children from Western or industrialized countries. As will be discussed below, although metacognition may be a universal ability, variability in cultural practices might modulate its manifestation in human behaviors. In the present research, we investigated a relatively early form of human metacognition, the sensitivity to what one knows or does not know. Importantly, our study concerned a non-"WEIRD" population (Henrich, Heine, & Norenzayan, 2010) by testing 4-year-old Yucatec Mayan children, a native population from Mexico.

A classical view in developmental psychology is that metacognition is related to mindreading (or theory of mind) (e.g., Carpendale, & Chandler, 1996; Flavell, 2000; Kuhn, 2000). This view assumes the following interrelated claims. First, metacognitive abilities require a conceptual understanding of mental states such as beliefs and desires through "meta"-representations of these concepts. This mental-state understanding is epitomized by success in a mindreading task, so-called a false belief task (attributing a false belief to others). This task is mastered by children around 5 years in Western cultures (e.g., Liu, Wellman, Tardif, & Sabbagh, 2008); metacognitive abilities are taken to appear only after mindreading has been mastered, manifesting themselves relatively late in human development around school age (e.g., Kloo, Rohwer, & Perner, 2017; Rohwer, Kloo, & Perner, 2012; Schneider, 2008). Second, any variation in the development of mindreading should map onto the development of metacognition.

Indeed, a study by Rohwer et al. (2012) showed that 3~7 year-old Austrian children's evaluation of their own knowledge states is a late developmental accomplishment. In classical studies, 3-year-old children understand that perceptual access (e.g., seeing a hidden content of a box) results in knowledge (e.g., Pratt, & Bryant, 1990). In addition to the conditions where children were allowed vs. denied a perceptual access to information (seeing vs. not seeing a hidden content of a box), Rohwer et al. (2012) tested the same children on another critical, partial knowledge condition: children saw two toys and were told that only one of them would be hidden in a box unknown to the children themselves. Children performed well in the typical conditions by reporting that they did (when they were allowed to see) vs. did not know (when they were not allowed to see), whereas in the critical condition, only children around the age of 6 accurately reported that they did not know which toy was hidden in the box.

Note that these findings concern the "concept-based" (or "explicit") metacognition (which requires a conscious application of the concept of knowledge to a given cognitive task). Evidence of metacognition in nonhumans suggests that "experience-based" (aka "procedural" or "implicit") metacognition (which depends on various heuristics based on felt fluency (e.g., how easily one comes up with an answer) rather than on a mastery of the concept of knowledge) does not require explicit, declarative representations of one's own mental states. Basic monitoring and control of one's own perception or memory seem to have evolved in a number of non-human species (Smith, Beran, Couchman, & Coutinho, 2008; Neldner, Collier-Baker, & Nielsen, 2015; Smith, 2009 for reviews). The first developmental study presenting evidence for experience-based metacognition borrowed an experimental paradigm from comparative psychology, in order to test non-verbally young children's metamemory (Balcomb & Gerken, 2008). In an "opt out" paradigm, 3.5-year-old children were found able to determine what they could remember in a procedural way, i.e. by skipping trials in which they were uncertain to succeed. In another study, Paulus, Proust and Sodian (2013) showed that 3.5-year-old children were able to implicitly monitor their memory (assessed by pupil dilation, for example) while failing to verbally report their confidence about their memory accuracy. Finally, even 20-month-olds have been found to request help only when they do not remember where a toy was hidden (Goupil, Romand-Monnier, & Kouider, 2016). These findings suggest that there are two forms of metacognition, the explicit or concept-based metacognition and the implicit or experience-based metacognition (see Heyes & Frith, 2014; Koriat & Levy-Sadot, 1999; Proust, 2013).

Recent studies have begun to assess and compare explicit and implicit metacognitive performances in the same individuals. For example, Kim, Paulus, Sodian and Proust (2016) conducted a study based on the design of Rowher et al. (2012), but with one exception. In addition to asking children to explicitly and verbally report whether they do or do not know the hidden contents of a box, the same children were asked to decide whether or not they would inform another ignorant person about the hidden contents of a box. Children overestimated their knowledge states in the critical, partial knowledge condition, thus replicating the findings of Rowher et al. (2012), whereas the same children tended to decline to inform another ignorant person. The authors interpreted this evidence as consistent with a dissociation between explicit, concept-based metacognition and implicit experience-based metacognition.

Notwithstanding the empirical fruitfulness of this line of work, all these studies exclusively focus on children from Western countries. Studies show that although the acquisition of the different components involved in applying to others a theory of mind (e.g., desire, knowledge access, false belief) is universal, the onset of the mastery of a particular component varies with culture (e.g., Lecce & Hughes, 2010; Liu et al., 2008). Additionally, even the universality of the acquisition sequence of the various components has been challenged (e.g., Shahaeian, Peterson, Slaughter, & Wellman, 2011). Therefore, despite the present lack of empirical evidence of metacognition in non-Western populations, we may expect that metacognition in its explicit forms – assuming it is related to mindreading as discussed above – is subject to cultural modulation (see also Heyes, Bang, Shea, Frith, & Fleming, 2020).

Moreover, as discussed above, experience-based metacognition is present in animals as well as young children and infants. In addition, such cues as fluency and felt uncertainty recruited for experience-based metacognition (e.g., Koriat & Levy-Sadot, 1999; Proust, 2013) are supposedly available in all humans in different cultures (e.g., Heyes et al., 2020). Therefore, experience-based metacognition may be universally present and less culturally variable than explicit metacognition. Nevertheless, experience-based metacognition may be not entirely immune from cultural influences. For example, one adult study shows that heuristic cues guiding experience-based metacognition are reported to be sensitive to external feedback (Loussouarn, Gabriel, & Proust, 2011). It is thus an open question whether experienced-based metacognition has its own developmental pace modulated by external factors e.g., how efficiently and automatically one recruits heuristic cues for implicit metacognition. Below, we provide background information about the Yucatec Mayan culture before turning to our study.

2 The Yucatec Maya

Yucatec Maya have lived for centuries in the Yucatec peninsula, a flat terrain covered with semi-tropical forest (the highest elevation is 210 meters). The Yucatec peninsula is located south of the tropic of cancer (19° 22′ N, 89° 12′ W). The eastern part, where the data were collected, is a tropical area covered with humid forest. The peninsula is located in the Atlantic Hurricane Belt and suffers regularly from hurricanes, especially because of its almost uniformly flat terrain. Temperatures reach 38–39°C during the day in the shade during the dry season (roughly from January to June). Fieldwork is conducted in various villages of Quintana Roo, Mexico (mainly Tihosuco and Kopchen). In these villages, the population was used to live mainly on subsistence corn farming, practicing a slash and burn type of agriculture. The main agricultural resources are corn, beans, squash, and other cucurbitaceous plants. People also make extensive use of the resources of the forest, notably for housing and extracting materials.

A typical Mayan family is patriarchal and consists of multiple generations living in the same household. More recently, however, a nuclear family household is increasing. It is also quite common that the extended family (i.e., grandparents, their children and grand-children) resides in several houses in the same compound. Traditionally married couples have around 8 to 12 children, but more recently (i.e., during the last 15 years) this number has lowered to 2.8 (INEGI). Childbirth used to take place at home in a hammock or on a chair (Jordan, 1989; Lave & Wenger, 1991) assisted by midwives. However, for the last 40 years, an increasing number of childbirth takes places in hospitals largely due to an effort on the part of the Mexican government arguing that childbirth at home is dangerous. As the medical system in rural Mexico fails to reach proper standards, however, the safety issue still remains.

Children take on many responsibilities early on – as young as 5 years old. They are often sent to make errands; for instance, going to the local shop to buy food or drinks, bring some ritual food to others members of the family in the village, to carry messages, etc. Children also take care of their younger siblings (Gaskins, 2000; Gaskins & Lucy, 1987). Generally, children are entrusted by their parents and any breach of this trust entails severe punishment.

Mayan villages throughout the peninsula are well connected by roads or trails. Transactions of material goods take place in town centers. The village also has several little shops for daily products. Electricity is available throughout the village and in the last few years the Internet as well, but phone signal

is not always present. Although the material culture is considered minimal (a standard house has only hammocks, a table, and some kitchen utensils), some households have modern furniture and devices (such as TV sets, refrigerators, etc.).

The majority of the population is catholic since the colonization by the Spaniards, but the religious belief is syncretic, which includes traditional Mayan beliefs. People believe in many types of supernatural entities, some of which were used in socialization processes (see Le Guen, 2012). A small part of the population is protestant and the proportion varies from village to village.

School attendance used to be very low, especially among girls. However, in the last 20 years or so, schooling has become compulsory (starting at age 4) and children are taught in Spanish. As children spend almost half of the day at school, a younger generation no longer takes part in traditional activities, especially boys who used to go to the field. Children, however, still contribute to everyday chores and provide a crucial working force during the busy periods of the fieldwork (Kramer, 2005). The majority of young people now graduate high school or even go to a university and/or find paid jobs in the city. Many of them return home every day or every weekend.

Yucatec Maya is a language spoken in the Yucatec peninsula in Mexico and in Northern Belize, with the number of speakers approximating 786,000 speakers in 2010 (INEGI, 2010). Yucatec Maya is a tonal language with VOS word order, although a number of focalisation and topicalisation processes are available (that make word order closer to SVO). It is a head marking ergative language (using two sets of markers, set A and set B: persons markers of set A mark the subject of a transitive verbal construction and possessive while markers of set B mark subjects of intransitive verbs as well as object of transitive verbs) with split ergativity constrained by aspect. Typical root profile is CVC with very productive inflection and derivation processes (mostly suffixes) (Bricker, Po'ot Yah &Dzul de Po'ot 1998; Lois & Vapnarsky 2006). Although Yucatec Maya is a written language, literacy in the script is very limited, and the vast majority of Yucatec Maya speakers, when they have to write, write in Spanish.

All women more than 50 years old are, in their majority, still monolingual in Yucatec Maya. Although most men and the younger generation speak some Spanish on a regular basis, the social interactions are mainly conducted in Yucatec Maya. Spanish is learned at school and used only with non-Mayan interlocutors. In the bigger villages people in the center speak both Maya and Spanish fluently and the younger generation is increasingly shifting to speaking in Spanish.

3 Present Research

In the present research, we examined implicit and explicit forms of metacognition in Yucatec Mayan children. We chose Yucatec Mayan children because Yucatec Mayan culture belongs to the group of non-Western and non-industrialized cultures, which prior studies on metacognition overlooked. Moreover, Yucatec Mayan culture provides an interesting test case of a variant of metacognitive development for the following reasons. Yucatec Mayan children are considered to be more autonomous than Western children, and their development follows an individual agenda, with little specific or direct adult instruction (Gaskins & Paradise, 2010). They are more accustomed to observational learning than child-directed or child-focused conversation and teaching methods, involving error correcting, strategic feedback, and question asking. As a consequence, Yucatec Mayan infants and children have been found to have different expectations and inferences about others' pedagogical cues and intentions. Shneidman, Gaskins, and Woodward (2016), for example, demonstrated that 18-month-old Mayan infants imitated a toy use regardless of whether they have been previously directly addressed or they observed another person's toy use (c.f., Csibra & Gergely, 2009). Thus, pedagogical cues have different relevance (less informative) to Mayan infants who are not frequently directly addressed to in their daily lives. Interestingly, even among US infants, those who had more experiences of observational learning than those did not better attended to and learned from observational learning (Shneidman, Buresh, Shimpi, Knight-Schwarz & Woodward, 2009). Granting that the metacognitive control of learning (e.g., whether to take up the information, what information to attend to) is shaped by learners' socio-cultural environment, and that metacognitive control and monitoring processes inform one another, one might expect that metacognitive monitoring – the ability to implicitly evaluate one's own knowledge states, and to explicitly report to others what one knows – is also shaped by culture (Heyes et al., 2020). In fact, meta-ignorance could result from practicing conversation with adults, even before mindreading provides them a conceptual understanding of a false belief (Harris, Bartz, & Rowe, 2017). Additionally, empirical studies show that external feedbacks and instructions directly and indirectly influence metacognitive judgments (Heyes et al., 2020). Note also that children's age in the present study is the age at which compulsory schooling starts, and thus the children's experience in formal schooling is relatively new. Receiving little formal training of this kind, therefore, Yucatec Mayan children may have less opportunities to introspect what they know. Despite a possibility of cultural modulation of implicit

metacognition as noted above, given the evidence for the early presence of implicit metacognition (e.g., Balcomb & Gerken, 2008; Goupil et al., 2016), we expected to find a dissociation between explicit and implicit metacognition in Yucatec Mayan children.

We adopted established paradigms (Kim et al., 2016; Kloo et al., 2017; Rohwer et al., 2012) in order to assess both explicit and implicit forms of metacognition among the same children. An explicit measure was obtained by asking children to explicitly state whether or not they knew which object was hidden in a container (Rowher et al., 2012). An implicit measure was obtained by giving children an option to either agree or decline to inform another person who did not know the hidden contents of the box (Kim et al., 2016).

4 Method

4.1 *Participants*

Nineteen 4-year-old Yucatec Mayan children participated in the study (8 boys, 11 girls, Mean age = 4.62 Range = 4.04 ~ 4.99). Achieved power was greater than .84 for the large effect size if the effect was present. All children were monolingual except for 3 children who were bilingual (Yucatec Maya/Spanish).

4.2 *Design and Procedure*

A female experimenter (a native Yucatec Maya speaker) tested each individual child in 4 different villages: Tihosuco (5,000 inhabitants), Tepich (27,000), Kopchen (500) and Kancabchen (with only 30 inhabitants). Children received two tasks, an 'informing task' followed by an 'explicit task.' In both tasks, there were three conditions across which children's own knowledge states concerning the hidden content of a box was varied. Children received 2 trials per condition. In the Full knowledge condition, children saw what was inside the box. In the Partial knowledge condition, children first saw two different objects and were told that only one of them would later be hidden in the box. Then, one of the objects was placed inside the box, while children's view was fully blocked. In the Ignorance condition, children did not see any objects but were simply told that an object would be hidden in the box. Again, children's view was fully blocked and an object was placed inside the box. In the informing task, in every trial, children were asked whether they would choose to inform another ignorant person, seating close to them, but whose view to the box and to the objects was blocked for the entire testing. If they agreed to inform, they were asked to inform the person. If they declined to inform, then the experimenter

informed the person. In the explicit task, everything stayed the same as in the informing task except that there was no ignorant person and children were asked to respond whether they did or did not know what was inside the box. At the end of the testing, children were presented with all the objects used in the testing and asked to name them. No child failed to name them.

4.3 *Coding*

Children's accurate responses were coded in both tasks. Informing task: In the Full knowledge condition, children received a score of 1 if they agreed to inform and accurately reported the object identity to the ignorant person and a score of 0 if they declined to inform. In the Partial Knowledge and Ignorance conditions, children received a score of 1 if they declined to inform or if they agreed to inform but verbally indicated their uncertainty or ignorance about object identities to the ignorant person (e.g., "Hmm," "I don't know"). Explicit task: In the Full Knowledge condition, children received a score of 1 if they correctly reported their own knowledge, and a score of 0 if they did not. In the Ignorance condition and the Partial Knowledge condition, children received a score of 1 if they acknowledged their ignorance in response to the experimental question.

Children's uncertainty gestures (e.g., head, shaking shoulders shrugging, looking away, head tilting) were also coded in both tasks. In the informing task, the time frame of coding was from children's indicating their decision of informing to their informing another person if they chose so. In the explicit task, it was from the moment when children were asked to explicitly indicate their knowledge states to their providing an answer. The experimenter and a second coder (blind to hypotheses) independently coded all the data. Inter-rater reliability was 100%.

5 Results

5.1 *Comparison between Informing and Explicit Tasks*

Figure 1 presents mean proportion of trials in which children provided accurate responses as a function of Task type and Condition. Accurate scores were analyzed by 2 (Task type: Informing vs. Explicit) X 3 (Condition: Full knowledge vs. Partial knowledge vs. Ignorance) ANOVA with both factors as within-subject factors. There was a main effect of Condition, $F(2, 36) = 5.82$, $p < .01$, $\eta^2 = .24$. Partial knowledge condition ($M = .32$, $SD = .32$) was significantly different from either Full knowledge ($M = .70$, $SD = .31$), $F(1, 18) = 8.41$, $p = .01$, $\eta^2 = .32$, or Ignorance condition ($M = .61$, $SD = .38$) $F(1, 18) = 12.55$, $p = .002$, $\eta^2 = .41$. The

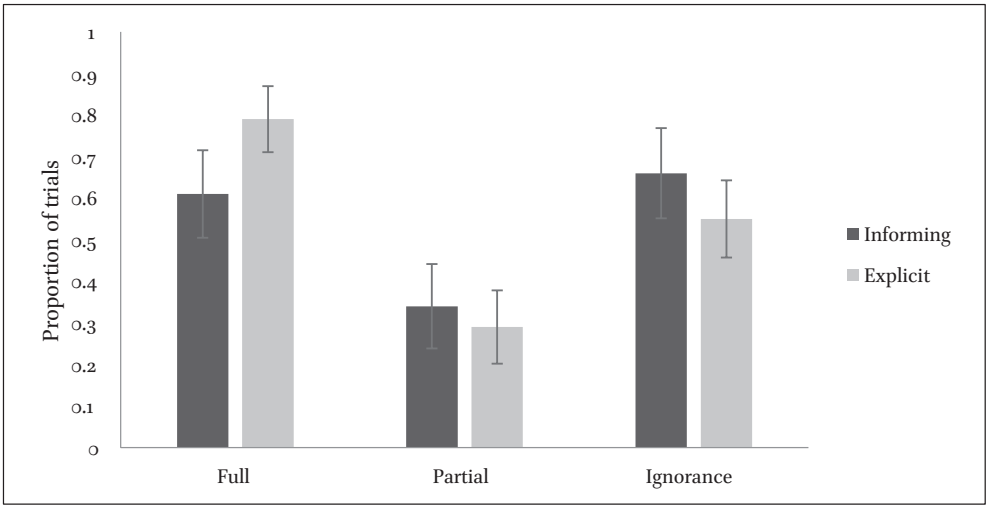

FIGURE 1 Mean proportion of trials of accurate responses as a function of Task type and Condition. Error bars indicate standard errors

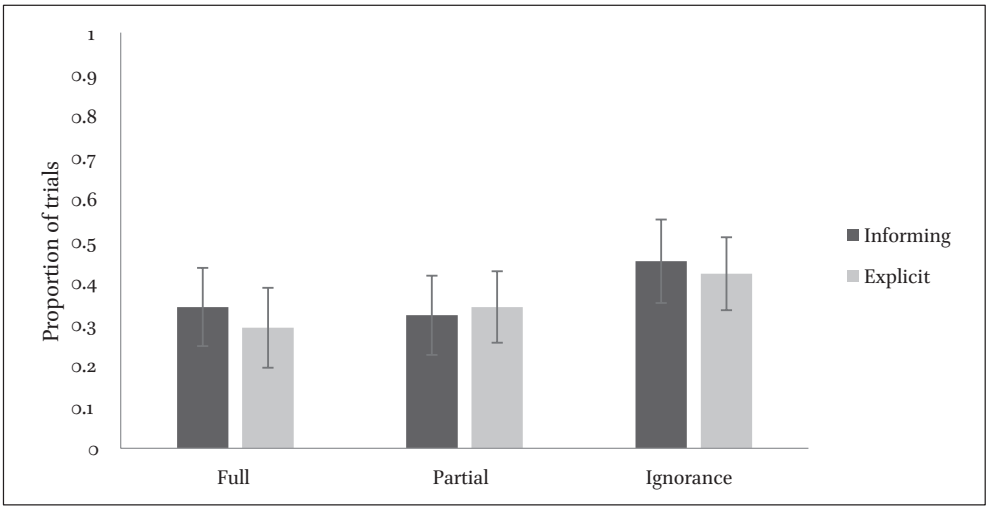

FIGURE 2 Mean proportion of trials in which children produced uncertainty gestures as a function of Task type and Condition. Error bars indicate standard errors

latter two did not differ, $F(1, 18) = .50$, $p = .49$. Task type was not significant, $F(1, 18) = .02$, $p = .89$, nor was the interaction effect, $F(2, 36) = 1.79$, $p = .18$.[1]

1 Logistic regression analyses produced exactly the same results for both metacognitive scores and uncertainty gestures.

5.2 *Uncertainty Gestures*

Figure 2 presents children's uncertainty gesture production as a function of Task type and Condition.

Children's uncertainty gesture scores were analyzed by 2 (Task type: Informing vs. Explicit) X 3 (Condition: Full knowledge vs. Partial knowledge vs. Ignorance) ANOVA with both factors as within-subject factors. None of the effects was significant: Task, $F(1, 18) = .04$, $p = .85$; Condition, $F(2, 36) = 2.09$, $p = .14$; Interaction of Task X Condition, $F(2, 36) = .14$, $p = .87$.

6 Discussion

In the present research, we tested 4-year-old Yucatec Mayan children's implicit and explicit metacognitive abilities of assessing their own knowledge states as a function of their perceptual access. We found that Yucatec Mayan children overestimated their knowledge in the Partial knowledge condition. We did not find, however, a better performance in the implicit, informing task compared to the explicit task. Below we discuss in more detail the following two issues: 1) Yucatec Mayan children's over-confidence bias 2) the absence of a discrepancy between implicit and explicit metacognitive abilities.

With respect to their explicit metacognition, Mayan children overestimated their knowledge by explicitly reporting that they knew which object was in the box in the Partial knowledge condition (in which they were shown two objects and simply told that one of them would be hidden but did not eventually see the hiding). Thus, a conceptual understanding of the causal link between perception and the corresponding knowledge states still undergoes development during preschool age and may become full-blown only around school age, as previously shown in studies of Western children (see Rohwer et al., 2012).

Prior studies report that, by 3 years of age, children understand the causal link between perception and knowledge tested by a complete absence vs. presence of perceptual access to a piece of information, similar to our Ignorance and Full knowledge conditions (e.g., Pratt & Bryant, 1990). The findings of Rohwer et al. (2012) are consistent with this picture: Austrian 4-year-olds were accurate about 84% of the times in the Ignorance condition, and, about 97%, in the Full knowledge condition (Experiment 1). Likewise, in Kim et al. (2016), German 4-year-olds were accurate roughly about 80% of the times in both Ignorance and Full Knowledge conditions. By contrast, 4-year-old Yucatec Mayan children were accurate about 80% of the times in the full knowledge condition but only 55% of the times in the Ignorance condition. Thus,

4-year-old Yucatec Mayan children in comparison to Western peers seem to explicitly over-attribute knowledge to themselves even in the Ignorance condition.

Contrary to our expectation, we did not observe a dissociation between implicit and explicit metacognition as in prior studies. Note that in Kim et al. (2016), in the critical Partial knowledge condition, 4-year-old German children were more sensitive to their own ignorance in the informing task than in the explicit task. The facilitating effect of the informing task observed in German children was not found among Yucatec Mayan children. Moreover, Yucatec Mayan children's uncertainty gestures did not differ depending on the conditions. By contrast, German children's frequency of uncertainty gestures varied by the conditions. In fact, Yucatec Mayan children rarely produced any gestures, let alone uncertainty gestures. Interestingly, Kloo et al. (2017) reported that 3- to 4-year-old Austrian children performed well in an implicit task in Experiment 2 (an information seeking paradigm) but not in Experiment 1 (a novel paradigm in which the task was to place an animal (a dog or a cat) in the right animal house (a dog house or a cat house) when knowing the animal identity or in a third place when ignorant of the animal identity).

How can we explain the present findings? Implicit metacognition seems to be present early in human development (Balcomb & Gerken, 2008; Goupil et al., 2016) and in other animal species (Smith et al., 2008). This form of metacognition is usually elicited when agents need to choose whether to perform a task or not (such as informing or requesting information), depending on their assessment of uncertainty related to that task. It draws on individuals' subjective feelings of knowing and feelings of confidence, which further guide their decision to act even in the absence of an explicit understanding of the underlying epistemic processes or states, involving concepts of knowledge or belief. Therefore, the explicit task in the present research tapped on children's understanding of the concept of knowledge. By contrast, in the informing task, children were not asked whether they knew what was inside the box. They were asked instead to decide whether or not to inform another person. Thus, informing decisions, in this sense, belong to implicit, experience-based metacognition.

The present findings raise the question whether implicit as well as explicit metacognition may be culturally modulated. One possibility is that Yucatec Mayan children's overconfidence about their knowledge reflects a cultural stance. Maya people tend to restrict the amount of information they deliver to others, which includes the facial gestures related to expressing uncertainty (Hanks 1993; Le Guen, 2018; Sauter, LeGuen, & Haun, 2011). In interaction with

others, adult Mayas carefully control the behavioral cues that might reveal their intentions and evaluations, and naturally adopt a "poker face". One interpretation of the low frequency of gestures (together with the absence of differentiation of uncertainty gestures across conditions) and their verbal report of their private inner states (knowledge in our study) in Mayan children is, therefore, that they follow a cultural rule of restriction of uncertainty display.

Alternatively, the findings may indicate Yucatec Mayan children's metacognitive bias. Adult studies show that calibrating one's own feelings of knowing or heuristic cues in general can be influenced by the external feedback (e.g., Loussouarn et al., 2011). It is also well known that children having had only limited opportunities for calibrating their own confidence in a task tend to be overconfident in predicting success in this task (see Schneider, 2008). The effects of external feedback on self evaluation and self regulation have been documented in adults, adolescents and school-aged children (Lipko et al., 2009; Rawson & Dunlosky, 2007; van Loon & Roebers, 2017). In general, modulating participants' experiences (e.g., through instructions) indirectly and directly influences their metacognitive judgments. As noted in the Introduction, given that direct instruction including feedback and corrections rarely occurs in a Yucatec Mayan culture, children may not have had ample task-oriented opportunities to calibrate their subjective feeling of knowing and to accurately report their knowledge. Given that experienced-based and concept-based metacognition are likely to be modulated by different factors (see, Logan & Crump, 2010), however, it is possible that despite the absence of the task difference in the present research the underlying determinants of Yucatec Mayan children's overconfidence are separate in each task.

Nevertheless, that Yucatec Mayan children display a metacognitive bias in the given tasks does not exclude a possibility that they may well display a highly advanced metacognitive ability and use it reliably in different tasks or contexts. There is some indication that while Mayan adults' public life is governed by "a doctrine of opacity" (Robbins & Rumsey, 2008) – that stipulates an understanding of others' mental states is difficult or even impossible and others' mental states are not subject to public discussion – people's complex interpretations of others' mental states which otherwise occur in ordinary conversation and interactions are delegated to other domains (e.g., dreams) (Groark, 2013). In a similar vein, children's self-reflection and self-evaluation including their private thoughts and mental processes may be exercised and developed in another realm. Thus, importantly, it is possible that implicit and explicit metacognition would be more readily elicited in tasks that children perform in their everyday lives. Metacognitive abilities are likely to be enhanced in coordinated joint actions as long as the parties involved

communicate about their respective feelings of uncertainty (see Shea, Boldt, Bang, Yeung, Heyes, & Frith, 2014). Assuming that such coordinated tasks are common across cultures, therefore, even young Yucatec Mayan children might display both forms of metacognition when performing tasks involving collective decisions. Future studies should address these possibilities by testing older children and in a metacognitive task that is modeled after activities that are prevalent and inherently important in their daily lives.

Acknowledgements

We thank Rebeca Petatillo Balam and Lorena Pool Balam for family recruitment and testing children, and Botagoz Beisekova for reliability coding. We also thank all the families and children who participated in the present research. We are grateful to comments and feedback we received from the DIVIDNORM Workshop held in Paris in June of 2016. We thank Markus Paulus for helpful comments on the manuscript. Finally, we would like to dedicate this paper to our friend and colleague, Martin Fortier, who encouraged us to pursue our effort to conduct the research and was always available to provide valuable feedback.

The research was supported by an ERC advanced grant (#269616) and an institutional grant (ANR-10-IDEX-0001-02 PSL) to JP.

References

Balcomb, F. K., & Gerken, L. (2008). Three-year-old children can access their own memory to guide responses on a visual matching task. *Developmental Science*, *11*, 750–760. doi: 10.1111/j.1467-7687.2008.00725.x.

Carpendale, J. I., & Chandler, M. J. (1996). On the distinction between false belief understanding and subscribing to an interpretive theory of mind. *Child Development*, *67*(4), 1686–1706. https://doi.org/10.2307/1131725.

Csibra, G., & Gergely, G. (2009). Natural pedagogy. *Trends in Cognitive Sciences,* 13 (4), 148–153. doi:10.1016/j.tics.2009. 01.005.

Flavell, J. H. (2000). Development of children's knowledge about the mental world *International Journal of Behavioral Development*, *24*, 15–23.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist*, *34*, 906–911.

Gaskins, S. (2000). Children's Daily Activities in a Mayan Village: A Culturally Grounded Description. *Cross-Cultural Research*, *34*(4), 375–389.

Gaskins, S., & Lucy, J. (1987). Passing the buck: Responsability and blame in the Yucatec Mayan household. *Annual Meetings of the American Anthropological Association*.

Gaskins, S., & Paradise, R. (2010). Learning through observation in daily life. In D. F. Lancy, J. C. Bock, & S. Gaskins (Eds.), The anthropology of learning in childhood (pp. 85–117). Walnut Creek, CA: AltaMira Press.

Goupil, L., Romand-Monnier, M., & Kouider, S. (2016). Infants ask for help when they know they don't know. *Proceedings of the National Academy of Sciences*, 113, 3492–3496. doi: 10.1073/pnas.1515129113.

Groark, K. P. (2013). Toward a cultural phenomenology of intersubjectivity: The extended relational field of the Tzotzil Maya of highland Chiapas, Mexico. *Language and Communication*, *33*, 278–291. https://doi.org/10.1016/j.langcom.2011.10.003.

Hanks., W. F. (1993). The five gourds of memory. In A. Monod-Becquelin & M. Fioravanti (Eds.), *Mémoire de La Tradition* (pp. 330–319). Paris: Société d'Ethnologie.

Harris, P., Bartz, D. T., & Rowe, M. L. (2017). Young children communicate their ignorance and ask questions. *Proceedings of the National Academy of Sciences*, *114*(*30*), 7884–7891.

Henrich, J., Heine, S. J., & Norenzayan, A. (2010). The weirdest people in the world? *Behavioral and Brain Sciences*, *33*, 61–135. doi:10.1017/S0140525X0999152X.

Heyes, C. M., & Frith, C. D. (2014). The cultural evolution of mind reading. *Science*, *344*, DOI: 10.1126/science.1243091.

Heyes, C., & Bang, D., Shea, N., Frith, C. D. & Fleming, S. M. (2020). Knowing ourselves together: The cultural origins of metacognition. *Trends in Cognitive Sciences*, *24*, 349–362. https://doi.org/10.1016/j.tics.2020.02.007.

INEGI (2020). Retrieved on May, 28, 2020 from https://inegi.org.mx/app/areasgeograficas/?ag=23#tabMCcollapse-Indicadores.

Jordan, B. (1989). Cosmopolitical Obstetrics: Some Insights from the Training of Traditional Midwives. (Featured article with comments by C. H. Browner, Robert A. Hahn, R. and P. M. Jeffery, Jean Lave, Carol P. MacCormack, and Lorna Amarasingham Rhodes.). *Social Science and Medicine*, *28*(9), 925–944.

Kramer, K. L. (2005). *Maya children: Helpers at the farm*. Harvard University Press.

Kim, S., Paulus, M., Sodian, B., & Proust, J. (2016). Children's sensitivity to their own ignorance in informing. *PloS one*. *11*(3): e0152595. doi: 10.1371/journal.pone.0152595.

Kloo, D., Rohwer, M., & Perner, J. (2017). Direct and indirect admission of ignorance by children. *Journal of Experimental Child Psychology*, *159*, 279–295. https://doi.org/10.1016/j.jecp.2017.02.014.

Koriat, A. & Levy-Sadot, R. (1999). Processes underlying metacognitive judgments: Information-based and experience-based monitoring of one's own knowledge. In S. Chaiken & Y. Trope (Eds), *Dual-Process Theories in Social Psychology* (pp. 483–502). New York: Guilford Press.

Kuhn D. (2000). Metacognitive Development, *Current Directions in Psychological Science*, *9* 178–181.

Kuhn, D., Amsel, E., O'Loughlin, M., Schauble, L., Leadbeater, B., & Yotive, W. (1988). *The development of scientific thinking skills*. San Diego, CA: Academic Press.

Lave, J., & Wenger, E. (1991). *Situated Learning, Legitimate Peripheral Participation*. Cambridge University Press.

Lecce, S., & Hughes, C. (2010). The Italian job?: Comparing theory of mind performance in British and Italian children. *British Journal of Developmental Psychology*, *28*, 747–766.

Le Guen, O. (2018). Managing epistemicity among the Yucatec Mayas (Mexico). In J. Proust & M. Frotier (Eds.), *Metacognitive diversity: An interdisciplinary approach* (pp. 193–222). Oxford ; New York: Oxford University Press.

Le Guen, O. (2012). The place of supernatural entities in Yucatec Maya daily life and socialization. In P. Nandedeo & A. Breton (Eds.), *Maya daily life. Proceedings of the 13th European Maya Conference* (*Paris, december 2008*) (Verlag Anton Saurwein).

Lipko, A. R., Dunlosky, J., Hartwig, M. K., Rawson, K. A., Swan, K.,& Cook, D. (2009). Using standards to improve middle school students' accuracy at evaluating the quality of their recall. *Journal of Experimental Psychology: Applied*, *15*(*4*), 307–318. https://doi.org/10.1037/a0017599.

Liu, D., Wellman, H. M., Tardif, T., & Sabbagh, M. A. (2008). Theory of mind development in Chinese children: a meta-analysis of false-belief understanding across cultures and languages. *Developmental Psychology*, *44*, 523–531. doi: 10.1037/0012-1649.44.2.523.

Loussouarn, A., Gabriel, D. & Proust, J. (2011). Exploring the informational sources of metaperception: The case of Change Blindness Blindness. *Consciousness and Cognition*, *20*, 1489–1501. https://doi.org/10.1016/j.concog.2011.07.001.

Markman, E. M. (1979). Realizing that you don't understand: Elementary school children's awareness of inconsistencies. *Child Development*, 643–655.

Mitchell, P., & Lacohée, H. (1991). Children's early understanding of false belief. *Cognition*, *39* (2), 107–127.

Neldner, K., Collier-Baker, E., & Nielsen, M. (2015). Chimpanzees (Pan troglodytes) and human children (Homo sapiens) know when they are ignorant about the location of food. *Animal Cognition*, *18*, 683–699. doi:10.1007/s10071-015-0836-6.

Paulus, M., Proust, J., & Sodian, B. (2013). Examining implicit metacognition in 3.5-year-old children: An eye tracking and pupilometric study. *Frontiers in Psychology 4*: 145. doi: 10.3389/fpsyg.2013.00145.

Pratt, C., & Bryant, P. (1990). Young children understand that looking leads to knowing (so long as they are looking into a single barrel). *Child Development*, *61*, 973–982. doi: 10.2307/1130869.

Proust, J. (2013). *The Philosophy of Metacognition. Mental Agency and Self-Awareness*. Oxford: Oxford University Press.

Rawson, K. A., & Dunlosky, J. (2007). Improving students' self-evaluation of learning for key concepts in textbook materials. *European Journal of Cognitive Psychology*, *19*, 559–579. https://doi.org/10.1080/09541440701326022.

Robbins, J., & Rumsey, A. (2008). Cultural and linguistic anthropology and the opacity of other minds. *Anthropological Quarterly 81* (2), 407–420. 10.1353/anq.0.0005.

Rohwer, M., Kloo, D., & Perner, J. (2012). Escape from metaignorance: How children develop an understanding of their own lack of knowledge. *Child Development*, *83*, 1869–1883. doi: 10.1111/j.1467-8624.2012.01830.x.

Sauter, D., A., LeGuen, O., & Haun, D. B. M. (2011). Categorical perception of emotional facial expressions does not require lexical categories. *Emotion*, *11* (*6*), 1479–1483. https://doi.org/10.1037/a0025336.

Schneider, W. (2008). The development of metacognitive knowledge in children and adolescents: Major trends and implications for education. *Mind, Brain, and Education*, *2*, 114–121. doi: 10.1111/j.1751-228X.2008.00041.x.

Shahaeian, A., Peterson, C. C., Slaughter, v., & Wellman, H. M. (2011). Culture and the sequence of steps in theory of mind development. *Developmental Psychology*. 47, 1239–1247.

Shea, N., Boldt, A., Bang, D., Yeung, N., Heyes, C., & Frith, C. D. (2014). Supra-personal cognitive control and metacognition. *Trends in Cognitive Sciences*, *18*, 186–193. doi: 10.1016/j.tics.2014.01.006.

Shneidman, L. A., Buresh, J. S., Shimpi, P. M., Knight-Schwarz, J., & Woodward, A. L. (2009). Social experience, social attention and word learning in an overhearing paradigm. *Language Learning and Development*, *5* (*4*), 266–281. doi:10.1080/15475440903001115.

Shneidman, L., Gaskins, S., & Woodward, A. (2016). Child-directed teaching and social learning at 18 months of age: Evidence from Yucatec Mayan and US infants. *Developmental Science*, *19*, 372–381. doi: 10.1111/desc.12318.

Smith, J. D. (2009). The study of animal metacognition. Trends in Cognitive Sciences, 13(9), 389–396.

Smith, J. D., Beran, M. J., Couchman, J. J., & Coutinho, M. V. (2008). The comparative study of metacognition: sharper paradigms, safer inferences. *Psychonomic Bulletin and Review*, *15*, 679–691.

Van Loon, M. H., & Roebers, C. M. (2017). Effects of feedback on self-evaluations and self-regulation in elementary school. *Applied Cognitive Psychology*, *31*(*5*), 508–519. https://doi.org/10.1002/acp.3347.

Wimmer, H., Hogrefe, G. J., & Perner, J. (1988). Children's understanding of informational access as a source of knowledge. *Child Development*, *59*, 386–396. doi: 10.2307/1130318.