

Editors

Mario Tokoro

Ken Mogi

Sony Computer Science Laboratories Inc., Japan

Creativity
and the *Brain*

Do Infants Dream of Baby Sheep?

What is the original meaning of the word "infant"? It comes from the Latin infans, which literally means "unable to speak." So, infants by definition do not speak. Usually, infants begin to utter words at around 12 months of age. They begin to toddle at around the same time. Every child experiences several stages of development: a fetus, an infant, a toddler, and finally a child.

The big question is this: how do we know the psychology of infants? In other words, do they count baby sheep when they cannot sleep? Given that infants do not speak, it is of no use asking them verbal questions. Is there any way of knowing how infants feel, what they think, or the reasons behind their behavior?

Professor Philippe Rochat does just that. He is an expert on the developmental psychology of infants. A gentle man from Switzerland, Professor Rochat has tender eyes and speaks with a mild French accent. His answer to the big question is called the "habituation/dishabituation method." Professor Rochat describes the paradigm as follows:

Suppose you are interested in knowing whether infants perceive colors, and in particular whether they can differentiate between primary colors such as yellow and red. You can figure that out by presenting infants with one of the two color cards over and over again. You will time infants' gazing at the card, and when you notice that they pay no more attention, you will flash the other color card. If the infants recover their visual attention, this suggests that they discriminate between the two colors.^a

^a Rochat P, *The Infant's World*, Harvard University Press, Cambridge, MA, 2001.

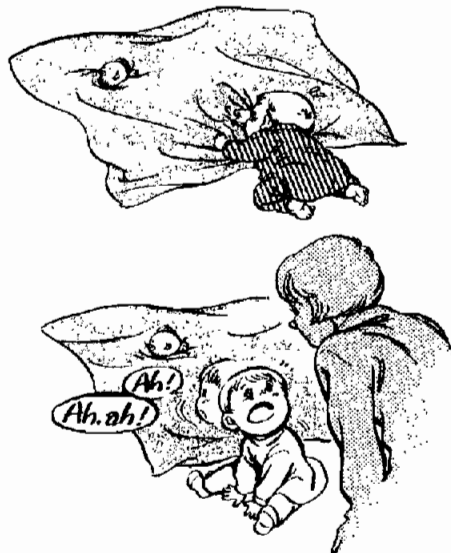
So, developmental psychologists do have means to infer the inner world of infants.

Professor Rochat says that, in order to understand the infant's world, we need to consider three aspects: the self, the object, and other people.

Infants first try to explore their own bodies. They discover the so-called "ecological self." The ecological self is the sense of their own bodies interacting with the environment. The ecological (physical) self should be distinguished from the interpersonal (social) self. This is close to the two basic kinds of self proposed by William James: "I" and "me."

Infants first explore "I," and then move on to discover "me." Infants then move on to explore physical objects around them.

Finally, infants begin to recognize other people. They gradually develop the sense of other people's minds, i.e. how they feel and why they behave the way they do. Infants recognize that the people around them are not merely physical objects, but have feelings and intentions as well. Infants learn to read people's minds — hence, the beginning of the reciprocal or dyad relationship: "you" and "me." This crucial step comes at around 2 months of age. Professor Rochat calls this stage the "revolution



What happens at 9 months?

with a smile" because it is characterized by the emergence of the first socially elicited smile. Parents recognize a "person" in their babies.

Of course, the three key elements — the self, the object, and the people — are interrelated: "Prior to this transition, infants cannot be taught because they do not yet understand that others are trying to teach them."^b Therefore, we need to consider the triad exchanges. At around 9 months of age, infants begin to understand the relationship between themselves, objects, and other people. Professor Rochat calls this stage "the nine months revolution." This new stage of development may be called the "revolution with a blanket." Why? Professor Rochat will explain to you in the following lecture.

^b Rochat P, *The Infant's World*, Harvard University Press, Cambridge, MA, 2001.

Creativity in the Infant's World

Philippe Rochat is a professor of psychology at Emory University, USA.



First of all, I want to thank you for inviting me. I hope my talk will help you. It is a great pleasure, and I really enjoy this workshop.

I would like to propose that a major bottleneck to creativity is "self-consciousness." This is a take-home message. What do I mean by self-consciousness? It is the understanding or awareness of being evaluated and perceived by others.

New Guinea, 1975

To give you a sense of the kind of research that we are doing and the origin of self-consciousness, I am going to start with an observation reported in the early 1970s by a visual anthropologist named Edmund Carpenter. Together with his team, he visited natives of New Guinea who lived in very dense forests with no mirrors, no reflecting devices, and

murky water all around; basically, having the experience of themselves through shadows and things that they were able to directly modify.

Edmund Carpenter and his team introduced video cameras, Polaroid cameras, and mirrors; and systematically recorded the reaction of native adults confronted, for the first time, with a clear view of themselves. What he observed was a systematic expression of great anxiety. After the first frightening reaction, the adults became paralyzed, covering their mouths and hiding their heads. They stood transfixed, looking at their own images, with only their stomach muscles betraying great tension. So, there was a negative or adverse reaction to the encountering with the self.

You might ask why. Why did these people behave like that? You might have anticipated that they would have been delighted, but this was not the case. I think this reveals a fundamental aspect of the human condition. Do you have any idea why? What came to their minds?

...

Steels: What comes to my mind is the difference between what they thought they looked like and what they actually saw in the mirror.

...

That is what I think, too. Not only did they recognize themselves in the mirror, but they also understood how other people saw or perceived them.

My mother is 84 years old. I just visited her. She is all broken down and has all the diseases you can imagine; but if you look at her eyes, she looks like she is 15 years old, and she feels like she is 15 years old. This extraordinary discrepancy — how one feels inside and what one projects to the outside world — that we all have is, I believe, a fundamental aspect of the human condition.

Let me quote from a book I found that captures very astutely the emergence of self-consciousness:

If no one is watching them, nothing is really happening to children. This is not some philosophical colloquium like that one of the tree falling in the forest and no one is hearing it. If you were very small, you actually understand that there's no point in jumping into a swimming pool unless they see you doing it. The child

crying, "watch me, watch me!", is not begging for attention; he's pleading for existence itself.

This quote captures very nicely what I am talking about. Without an audience, we are reduced to nothing. When we write a book, paint, or play music, we have an audience. We are fundamentally and basically social. We cannot think about commission outside of others. Similarly, creativity cannot be conceived as an isolate, solitary, autistic kind of activity. There are always people out there.

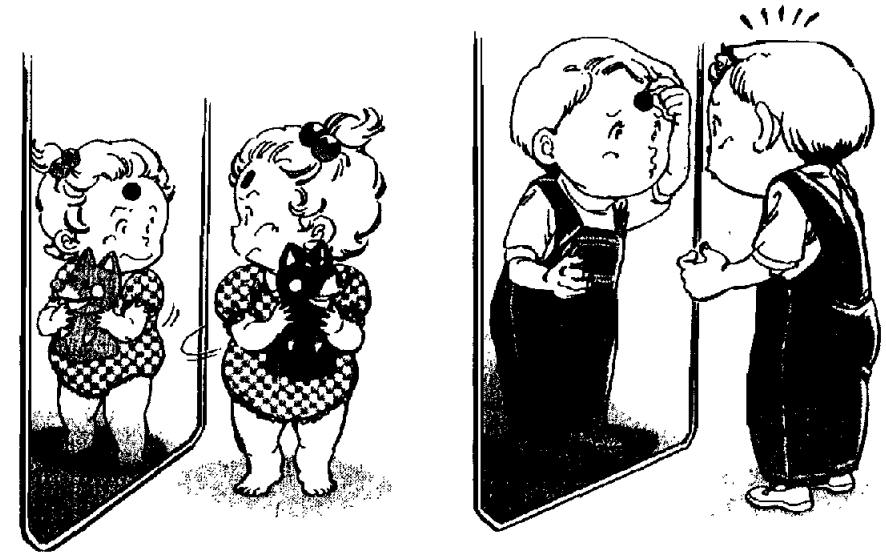
Would You Like a Rouge Spot on the Forehead?

The question that we have been addressing for some time now in the lab is how to go from self-perception — perceiving the body by breathing, crying, or moving — to recognizing oneself in a mirror, which happens at around 14 months of age.

Is everyone aware of the rouge task? Usually, we tap the forehead of a child and leave a big sticker under the hairline, so he or she does not feel it. Then, we confront the child with the image in a mirror; the test is whether the child tries to move or touch the sticker. This test was invented by Gallup *et al.* (1971)⁵ to see if chimpanzees could recognize themselves in the mirror.



It is observed that, at about 14 months, children do touch or try to remove the sticker. This seems to be quite universal across cultures. More interestingly, mere self-recognition develops very rapidly into a manifestation of embarrassment: at about 18 months, children try to not only touch or remove the mark on the forehead, but to also vanish from the public eye by hiding their faces and looking downwards. We tested this experiment on children up to 3 years old, and the reactions were similar. Children recognize that they are different from others, and do not like it. There is this propensity of the self, which is related to Allan Snyder's talk about conformity.



We also tested the children in our lab in front of the mirror when everybody in the lab had a sticker on the forehead. In general, there is a lack of embarrassment when the sticker is created to appear normal in the lab. The children do not get embarrassed if everybody else has a sticker on the forehead, and seem pretty happy to be the same as other people.

Furthermore, some children in our experiment clearly experience the equivalence between the other and themselves. So, upon discovering this,

⁵ Gallup GG Jr, McClure MK, Hill SD, Bundy RA, "Capacity for self-recognition in differentially reared chimpanzees," *Psychol Rec* 21: 69-74, 1971.

instead of taking away their own sticker, the children take the experimenter's sticker and put it on their own foreheads.

...

Snyder: Is that before they look in the mirror?

Rochat: No, the mirror is lifted. So, it is really the experience of the normal: we all have stickers, and we are all part of the same clan. This fits perfectly with the idea of affiliation, the idea that we are not different.

Snyder: It's amazing.

...

In another experiment, we tested two children: a 2½-year-old girl and her 4-year-old brother. We asked her brother to sit behind her and to keep silent, while we tested the girl first with a sticker. They both did not know that they had a sticker until they saw it in the mirror. However, when the boy looked at the mirror and realized that he had one, he shook his head — this is the crucial point — he wanted to take it off, but then he decided not to. He was very much aware or self-conscious that he had a sticker on, and his first gesture was to try to remove it; but then, he very quickly decided not to, since everybody else had one as well. So, look at the little boy and the inhibition: he realized that he also had a sticker, he shook his head, and then just let it go. I think this is pretty interesting.

...

Steels: He is bright.

Snyder: And he fits so well.

...

Now, creativity is based on the fact that we are different. Perhaps creativity is trying to break this need for others, this need to align with others. So, in order to be creative, if I follow Allan's ideas, uniqueness must be secured. Think about your own family, Allan! All three brothers have won big prizes and are famous — this is, I think, a fact of the matter you

had highly driven, passionate, eccentric parents as role models. You wanted to be accepted by your parents by being out of the ordinary. If you were ordinary, you might have been rejected by your parents!

...

Snyder: I think all these ideas about individuality and the need for others, etc., are brilliant.

...

We Are Made to Differentiate from the Start

For a long time, pioneers of developmental psychology like Piaget and William James have had this idea that babies are born in a state of confusion or duality in the world, and that they progressively distance themselves from the world. In other words, we gradually objectify the world and differentiate ourselves as independent entities from things that happen outside to eventually become philosophers and scientists, among others, as adults.

However, my research — and infancy research in general — shows that this idea is wrong. We start with the means to differentiate ourselves from the world to begin with. Babies, from birth onwards, experience their own bodies as differentiated entities in the world. I will briefly show you how.

The first object of investigation and exploration is the physical body. Babies move, explore, and touch their own bodies; they hear themselves. This is a primary experience which occurs very quickly by serendipity or fortunate accidents, as described by Piaget (1953).^d Babies have an affect or influence on things, and they discover their own affectivities in the world. They are agents in the world.

For example, when my daughter was 3 months old, I attached a mobile above her crib one day while she was laying in it. This is what I caught her doing: she lifted her left leg up and discovered the mobile, and then systematically moved the mobile to create an interesting visual

^d Piaget J, *The Origins of Intelligence in Children*, Routledge & Kegan Paul, London, 1953.

experience. What is interesting here is that she kicked, stopped for a while to watch, and then kicked again. She kept doing this for 45 minutes. She was completely mesmerized, not by the mobile, but probably by her affectivity on things in the world.

Before 3 months, babies make perceptual experiences that are unique, thus specifying the body as being differentiated, situated, and agent. I will now demonstrate this to you.

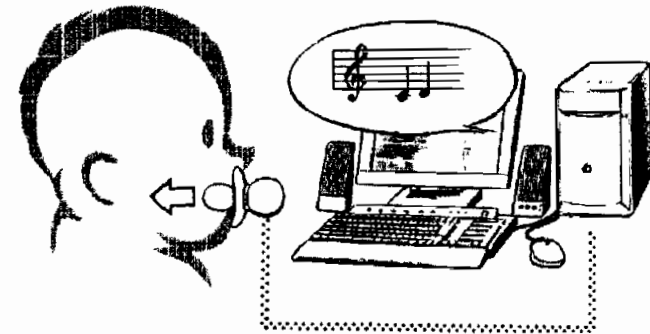
The first thing that is checked at birth is that the baby's lungs are working; if the baby is not crying, we typically hit the child so that he or she will start to breathe. The sound production is primary, and so only the baby can make the experience of himself or herself crying, which sounds very different because of the mixed auditory feedback with proprioception (your "body image"; i.e. the system by which you know where all of your limbs are in relation to the rest of your body, and which informs you of your own bodily movements) and the very complex backed-up stimulation.

As another example, when kids bring their foot in contact with their hand, they make the experience of the so-called "double touch." The foot feels the hand and, simultaneously, the hand feels the foot. This is a perceptual, unique experience, which specifies the body as a differentiated entity in the world.

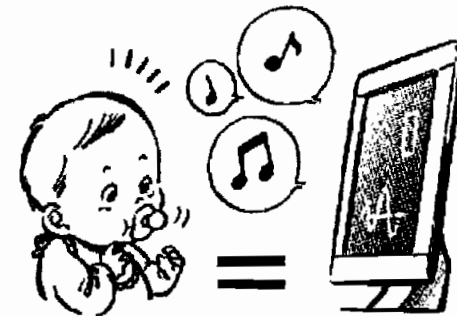
Do babies differentiate between the self-touch, double touch, and single touch? To determine this, we conducted a very simple experiment based on the fact that, if we stimulate a body region of newborn, typical, healthy babies, they will ordinarily try to suck in the direction of the stimulation. This is a very robotic response that we can expect from every newborn. We tested newborns that were less than 24 hours old, comparing the routine responses in the case of self-stimulation (when they brought their own hands spontaneously to their face) and when the experimenter stimulated a region of their face. The question was whether there was a differential moving response between self-stimulation and other stimulations (i.e. double touch or allowed stimulation). We found that babies groped significantly more to the stimulation by the experimenter's finger compared with self-stimulation. This very simple observation proves that babies do make perceptual discriminations between self-stimulation and other kinds of stimulation.

With respect to causality and affectivity in the world, I would just like to show you one little experiment that, I think, drives at my point: very early on, babies do have a sense of themselves as agents in the world, and it does not seem to be an instrumental conditioning.

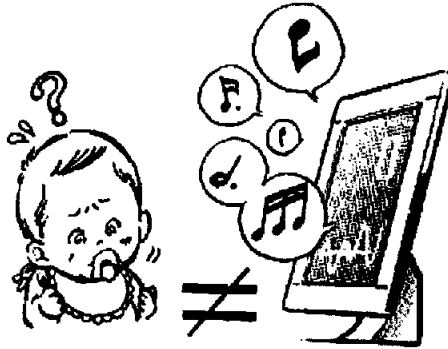
This experiment involved 2-month-old babies, each of whom held a pacifier that was connected to a computer, which recorded the positive pressure that the baby was applying on the pacifier. When the child applied pressure above the threshold, the computer generated a sound. Basically, we introduced a musical instrument into the baby's mouth.



For some babies, each time they applied pressure above the threshold, they heard a sound that varied proportionally in pitch. So, it could go like this: tu-tu-tu-tu-tu-tu-tu-tu-tu-tu. This is an auditory analog of the activities on the pacifier.



In another condition, each time the baby pressed the pacifier above the threshold, he or she heard a sound that was not analog to the pressure. So, it could go like this: tu-tu-tu-tu tu-tu-tu-tu. This is a random pitch. In other words, frequency was changed.



We asked two questions: whether 2-month-old infants noticed that the sound was produced, and whether they could discriminate between analog sounds and nonanalog sounds. If they could discriminate, it would mean that babies are engaged in exploration, and that it is simply an instrumental (operant) conditioning.



This picture shows a baby with a pacifier, but he is very unhappy. Look at his facial expressions, his eyebrows. There is no sound. Then, suddenly, the child hears sounds. The child freezes; there is much more concentration.

We found that the sucking response was markedly different in the analog condition compared with the nonanalog condition. In the analog condition,

babies were more subdued in their oral response. They tried to explore their abilities to produce sounds that reflected their own proprioception.

One thing that is quite remarkable is that when the babies started to hear the sounds they produced, they tended to explore the threshold. Kids do not simply reproduce something that makes an effect — they discriminate the kind of effect that more or less reflects what type of action they are producing on the object.

What is interesting is that when we tried to reproduce or replicate this result with newborn 24-hour-old babies, who are very good at sucking and whose auditory system is fully developed immediately after birth, we could not find a differentiation between the analog and nonanalog conditions that exists in 2-month-old babies. This therefore represents a crucial development in terms of understanding their own bodies and activities in the world.

Another study shows that very young babies have a sense of their own bodies situated in the world. In this experiment, babies were presented with objects that were placed either just in reach or slightly out of reach by a few centimeters. The infants would then decide whether or not to reach for the object, depending on the perceived reach ability of the object to the body. We did a series of experiments that showed that by 4 months, babies have a very strong sense of what they can and cannot do by judging the world. They are situated with respect to objects in the world.

First Psychological Revolution: 2 Months

By 2 months, something very important happens: the emergence of smiling, the emergence of reciprocity. I would like to propose that this is the actual “psychological birth” of the baby.

This is not the biological birth, because we know that the first 6 weeks of a healthy infant’s life are basically in perfect continuity with the behavior that the baby manifests during the last semester of pregnancy. Prechtl^c demonstrated that there is a remarkable behavioral continuity between prenatal and early postnatal development.

^c Prechtl HFR (ed.), *Continuity of Neural Functions from Prenatal to Postnatal Life*, Cambridge University Press, Cambridge, UK, 1991.

At 2 months, a profound change occurs: the emergence of smiling in a face-to-face interaction, as emphasized by Schaal, Ruff, and others. It is also, from the adult perspective, the time when parents and caretakers start to recognize a "person" in their baby, and not simply a "thing" that cries for their care. If you look at diaries of mothers and fathers, you will systematically find explanations or remarks with great emphasis on the discovery of the first socially elicited smile, not the reflex or automatic smile of the newborn. This is seen as an exchange in reciprocity, and is a major developmental step.

...

Snyder: That's interesting, but what about a study of breast-feeding and eye contact, the concentration of the baby on the mother's eye? This occurs even earlier than the emergence of smiling.

Rochat: Well, but there is no coconstruction of affects in breast-feeding. Actually, something very important does happen around the same age in the way children look at faces. By 6 weeks, when babies start to smile, there is a transition in behavioral organization at very basic levels such as visual attention. Children's visual attention is very different prior to and after 6 weeks.

You have to observe, to answer your question, how babies at 1 month versus 2 months attend to faces by looking at their eye movements, and seeing where in the face they look at. At 1 month, as you know, they focus on the high contrast outline and outside features of the face. At 2 months, they become much more interested in the internal features of the face.

...

Prior to 6 weeks, you can clearly see that babies' eyes are wondering in the periphery, not paying attention and not having much eye-to-eye contact, which is so crucial for reciprocity.

Reciprocity is expressed in early imitation. There are now a dozen experiments on babies showing that by 6 weeks, they tend to reproduce the facial gestures expressed by adults.

Meltzoff, a pioneer of this new wave of early imitation studies, published one study that I find particularly meaningful. He tested 6-week-old babies when facing an adult pulling his or her tongue out (i.e. tongue protrusion). The direction of the tongue protrusion varied: it was either at the midline or to the side (left or right) of the experimenter. What Meltzoff showed in his very minute and delicate analysis was that by 6 weeks, infants tended to reproduce not only the tongue protrusion as a whole, but also the tongue protrusion and the detail of its orientation. This indicates that children do not simply release a mechanism of reproduction, but demonstrate some rudimentary effort to match and explore the model and their own bodies.

...

Snyder: And that's at 6 weeks?

Rochat: Yes. Meltzoff did not try this experiment on newborns, but he was sure that it would work as well. However, I am sure that it will not work for newborns because, in my opinion, children only start to open up during the "2-month revolution."

...

What is interesting in terms of learning is reciprocity. You smile, I smile, and so there is this matching of emotional expression. We conducted an experiment in which babies were either facing themselves in front of a large TV screen or facing an adult experimenter who mimicked their movements. The experimenter did exactly what the baby did; for instance, if the baby clapped hands, the experimenter immediately clapped hands as well. We found that at 4 months of age, infants reacted very differently to their own images compared with the image of an imitating adult. They smiled more at adults, and vocalized much more at themselves. So, basically, they can make a discrimination between themselves and someone else.

...

Mogi: Did you measure the mean temporal delay in the others' condition?

Rochat: Yes, we used a time machine that allowed us the online delay that is used in broadcasting. Imagine a commentator who spills his coffee during a football game and cries, "Shit!" You have to cut that part away, so you need to buy seconds of delay. We did some kind of psychophysics of when the children started to disconnect with the visual figure. Typically, 3 seconds is the window around which they start to notice the delay. But, it's remarkable how tolerant to the delay babies can be.

Mogi: So, you mean a strong response to the self-image stops at 3 seconds?

Rochat: Yes, 3 seconds. But, this is a complicated issue because whether there is a delay or not is absolutely contingent. Every time I do something, the visual feedback does something. So, if there is a time delay, there is no coincidence over time, but there is always a coincidence over what is happening. It's complicated. To illustrate this point, we conducted an experiment whereby we borrowed a paradigm from Trevarthen, who did a study with Elizabeth Murry some time ago.

We observed a mother and her baby in separate rooms, and both of them communicated with each other live via a closed-circuit video system. In another condition, the baby was presented with a replay of the mother in a previous session. So, the mother looked happy, but was not attuned or sensitive to what the baby was doing. There was no feedback.

What Trevarthen and his collaborators found — and we somehow replicated — was that babies between 2 and 4 months started to manifest differential responses to their mothers that were either live or in playback. They showed different attitudes.

...

We did another experiment: the experimenters played a routine peek-a-boo game with babies. They were trained to do a certain number of gestures that fit the peek-a-boo game, which is a universal teaser to babies. Babies love it: "look-look-look, peek-a-boo, yeeees." It has this universal envelope from the crescendo of tension to the release of tension. But, in one condition, the experimenters heard instructions in the earphone to

"scramble" the peek-a-boo game. They were told to deliberately disorganize the peek-a-boo game.

We tested 2-month-old, 4-month-old, and 6-month-old babies. At 2 months, babies responded equally to the scrambled and the organized peek-a-boo game. By 4 months, they responded significantly less to the scrambled game compared with the organized peek-a-boo game. This means that by 4 months, infants expect a certain form in the exchange or reciprocation of a dialog.

Second Psychological Revolution: 9 Months

Let me now come back to the central point of this talk. By 9 to 18 months, there is an emergence of coawareness. To illustrate this point, we borrowed Meltzoff's paradigm and expanded it a little for our experiment (Meltzoff is a very creative experimentalist).

Babies were faced with two experimenters. Both of them were of the same gender (female), looked the same, wore the same blue apron, and had the same swept-back hairstyle. Both of them had the same toy, which in this case was a little cube or a little ball. The baby sat on the mother's lap; and one of the experimenters was trained to imitate exactly what the baby was doing with the cube, while the other one did something that was not equivalent to what the baby was doing. So, again, here is an analog/nonanalog situation. We looked at what the baby did.

We found that by 14 months, babies paid much more attention to the person who was imitating them. They even tried to trick the person who was imitating them by engaging in an action, and then stopping suddenly to throw the imitator off balance. At 14 months, infants start to recognize themselves in others — others are becoming "social mirrors." The others are used to consolidate the first implicit, and eventually explicit, identity of the self.

Let me get back to my main point: self-consciousness is a bottleneck to creativity. We did a famous Piaget experiment: putting an (attractive) object on a blanket, and seeing when babies come up with the creative idea of pulling the blanket to get this object. Piaget claimed that this kind of pulling action emerges in 9-month-old babies. We tested the same task on babies aged 14 and 18 months old.

We found that by 9 months, 90% of babies pulled the blanket to get the object; however, by 18 months, the percentage was close to zero. Why didn't they do it? Because they knew that their mother was sitting near them. So, they saw the object and then went "ah, ah, ah, ah."

Of course, they could pull the blanket to get the object. They are perfectly capable of doing that. But, that is meaningless. What is important is not the physical task of getting this object; rather, the problem to be solved becomes social. The goal is collaboration and affiliation, not grabbing the object. Essentially, people, not the objects, become the focus of attention. This happens at around 14 months or later.

Conclusion

Since we started out by talking about the islands in the Pacific, let me just drop a few images here. We did all kinds of tests on babies in Samoa and Fiji. We looked at the mother in interaction, and tried to see if there were any intrinsic differences between what we observed in Atlanta (USA) and in the Pacific, where the culture is radically different. In the Pacific, there is no privacy, 40% of the kids are adopted, and kids are surrounded by very different sets of values.

What we observed was that at 14 months, babies requested for help when trying to open the box. Therefore, this behavior emerges at about the same age and is universal. I do not think that it is innate, but I think there are some basic competencies that come from social transactions.

So, this is the conclusion: self-awareness — the bottleneck to creativity — is not the awareness of the body, the ecological self, or what is situated in the world. It is essentially the "coawareness" or the awareness of the self as seen through the eyes of others.

I would like to finish with a piece of writing by one of my students. It is very validating for me as a teacher, but it is also very tragic. It is a tragic testimony of higher education in one of the most powerful (and currently damaged) countries, the USA. The student is very smart, a high-honors student.

I have not had one serious discussion about creativity in a single class in my 3½ years in college. Not one. This class is my first exploration of creativity. And the insight I have gained is invaluable. I love the idea of the art of the drift (which is

something I developed]. People in general write or talk about the clear agenda, the goal. But, it is the very act of writing or talking, the process, that is critically important. This is a principle of creativity. The greatest discoveries were made by accident, not by intention. I, for one, am a believer in the process.

So, I find it quite extraordinary that higher education is devoted so much to the accumulation of knowledge; however, there is no reflection on what it takes to become creative. This workshop is really a great opportunity to reflect on creativity. Thank you very much.

Further Reading

Rochat P, *The Infant's World*, Harvard University Press, Cambridge, MA, 2001.