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Language-Trained Animals: A Window to the "Black Box"

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ABSTRACT

Animals have to process quantity of information in order to take decisions and adapt their behaviors to their physical and social environment. They have to remember previous events (learning), to cope with their internal (motivational and emotional) states and to display flexible behavioral responses. From a human point of view it is quite impossible to access all those information, not only because of the sensorial channels used that can vary but also because all the processing phase occurs in the "black box" and non-human animals are not able to express verbally what they think, feel or want. Though useful information might lie in the "collected data" (animal mind), extracting them into insightful knowledge with human-accessible form (clear meaning, no interpretation) presents a demanding and sophisticated undertaking. Several scientists decided to trained different individuals from several species (apes, dolphins, grey parrots, dogs) in order to teach them a new communicative system that they could share with us. Here, the different studies (techniques and species used) are presented, the constrains but also the main findings.

Keywords: Cognition; Human-Animal Interaction; Language-Trained Animals; Referential Communication

1. Introduction

Humans are curious by nature and want to increase their knowledge about their environment. In a developmental and philosophical point of view they are interested in: "what makes human different from other species" and "how this human species evolved". There is more and more evidence of animal sentience and consciousness nevertheless it is a hard job to know exactly what they want and how they see the world. The interspecific communication is complex and often not complete because of differences regarding modality and integration of the signals.

Several studies have been conducted in ethology, behavioral ecology, comparative psychology and cognition in order to "ask" other species: What do you see? What do you want? Studies in the field, using playback paradigm for instance revealed complex communicative abilities in different species such as birds or primates [1]. The different developmental trajectories of vocal production, usage, and response create an oddly asymmetric system of communication in which a small repertoire of relatively fixed calls, (each linked to a particular context), can nonetheless give rise to an open-ended, highly modifiable, and cognitively rich set of meanings. Recent studies of baboons and eavesdropping songbirds provide examples of species in which constrained vocal production and usage by signalers provides listeners with extensive information about their social environment [2]. Many studies have been conducted in the lab in order to control as much as possible the quality and quantity as well as the nature of the stimuli and to look at the animal response even in a complete artificial environment and non-relevant task. Operant conditioning has been extensively used in order to study animal behavior as well as language ability [3]. Then it is also possible to look at individual preferences when given a choice (for space, social partner, type of food, etc.) and also to look at their behavior when facing ambiguous stimuli they were not trained to respond at. Indeed, cognitive bias is a non-invasive technique to evaluate internal states and mood. As well as expectation violation and incentive contrast are paradigms that can be tested with animals but also with infants… which mean different species without language (verbal) ability. Nevertheless it is easier when it is possible to share thoughts, intentions, perceptions, etc. through direct communication.

Because scientists still did not find the ring of King Salomon—the object with which the king could talk to the animals—they have tried different (sometimes co plementary and not all fruitful) strategies to teach animals to communicate with people in a human-designed language. Interspecies communication is a powerful mean of studying animal cognition. It also a good opportunity to know how they perceive the world (color, contrast, optical illusion), what are their preferences (food, toys, etc.) and their thought. This system offers the possibility to interact directly, asking questions and also to compare the results between species (included humans). Interspecies communication could also bring some answers about human language roots and evolution. The major constraint is that the communication code has first to be taught, which is time consuming.

The first species, the scientist focus on, where apes because of their genetic proximity. Researchers also work with marine mammals because of their large brain. One scientist decided to work with a parrot. African grey parrots have good vocal mimicry ability. Because birds are able to reproduce exact human words, intonations and even laugh, people invest emotionally and attribute intentions easily. Even infants treat parrot vocal production as human ones [4]. Parrots have a very different vocal tract and different brain structures compared to humans nevertheless present some analogies in the vocal learning and production process [5]. Hand-reared individuals are also sensitive to human behavior [6,7] and given cues [8]. Despite their relative brain size, compared with mammals, psittacidae birds had larger brain that expected (compared to their body size) and display elaborated behaviors when facing physical and social problems [9]. More recently, a Portuguese team decided to start the adventure with a dog. Different techniques have been created and used according the species (motor capacity mainly) but not only. The production of arbitrary signs has been documentted in several "linguistic" animals submitted to long-term and intensive contact with humans. Washoe and other chimpanzees, bonobos, gorillas and orangutans were trained in the use of American Sign Language [10-12]. Alex, a grey African parrot, was shown to produce and apply English labels, answering questions and making vocal requests [13,14]. In other cases, production skills were installed through concrete, external interfaces which make the production process easier and permit testing communication competence in contexts spatially and temporally distant from associated objects or activities. The chimpanzee Sarah placed colored plastic chips, each one standing for a word, on a "language board" [15]. Duane Rumbaugh developed a computer controlled system, the keyboard which held keys with different lexigrams (arbitrary visual signs) [16]. Lexigrams have been used with chimpanzees and bonobos and more recently with a dog. Non-primate species, such as dolphins, have also been shown to be able to use levers or keys instrumentally: the bottlenose dolphin Akeakamai was able to report yes or no, by pressing paddles, in response to gestural questions about the presence of specific objects in her tank [17]. Working with these species represent many constrains regarding the time necessary to familiarize, socialize and trained the animals and also the cost of the housing and care. Recent research points to the existence of a complex and successful communication process between humans and dogs, which may have been selected for during domestication [18,19]. Investigation of doghuman communication has been largely conducted on comprehension abilities (discrimination of verbal commands and obedience training [20,21], word-object associations [22], human given cues such as pointing or gazing [23-27] and much less on the production side. Experimental studies show that dogs signal motivational state through acoustic features of barks [28,29] or use body orientation, gazing, going to and fro to direct the owner's attention both to themselves and to a place of interest in the environment [23,24]. Barking and gazing are spontaneous, species-specific components of the communication repertory of dogs. Dogs are already living in human houses and they do not need to be extensively familiarized. Dogs are also attentive to the attentional state of humans [30,31] and can attribute visual perspective taking [32]. That's why this species represents a good model to develop a new common communicative system.

In this review, different type of techniques used to teach an artificial communicative system will be presented and the species involved. In order to illustrate the diversity and complexity of the behaviors that the scientists observed examples of several studies would be presented.

2. Methods and Animals

2.1. Apes

2.1.1. Human Words

The first attempts of communication were to raise apes in human family so that they could learn to speak. Gua (chimpanzee of the Kelloggs) was able to imitate motor actions but not human speech [33]. Viki, a chimpanzee, has been raised as a human child with Cathy and Keith Hayes in order to learn human verbal language [34]. Nevertheless due to anatomical configuration (Vocal cords are placed higher in the vocal tract compared to humans and the tongue is bigger), apes are not able to modulate the sound enough to reproduce human words. Viki succeed to reproduce only very few words (3 or 4). The natural vocalizations production is link to emotional state of the animal and thus hard to control and modulate on the contrary to intentional shared communication.

2.1.2. Sign Language

Scientist decided to use American Sign Language and to teach "words" to apes. Humans produce the sign in front of the apes. The animal learns through observation and also with hand modeling (from humans or other ape). The individual has to shape his hands in a specific way and place and/or move them appropriately for each word. This method, used with deaf humans seems relevant to communicate with another species.

Beatrix & Allen Gardner and then Roger Fouts teach Washoe, a chimpanzee, the simplified American Sign Language [35,36]. Other chimpanzees (Loulis) and bonobos (Kanzi) learned to sign. Francine Patterson did the same with Koko and Michael, two gorillas (Gorilla gorilla) and Lyn Miles with Chantek (Pongo borneo) [12], an orangutan. All those apes learned more than hundreds of signs [37].

2.1.3. Lexigrams

Ernst von Glasersfeld developed the language that Lana learned to use: he coined the term "lexigram", created the first 120 of them and designed the grammar that regulated their combination at Yerkes National Primate Research Center. Lana was the first chimpanzee that learned to use lexigrams [16]. Each symbol refers to a person, an object or its characteristic, an action or some general concept such as good, bad, yesterday, etc.

Other chimpanzees (Panzee, Sherman) but also bonobos (Panbanisha, Kanzi, Nyota) have been taught (or learned through observation) and tested with this method. Although Kanzi learned to communicate using a keyboard with lexigrams (through observation), he also picked up some American Sign Language. Kanzi & Panbanisha were able to imitate human words but also indicate (by pointing at their mouth and throat) their difficulty to vocalize. So able to control their vocal production, in the same way that they develop some dexterity to sign [38].

2.1.4. Object Combination

Ann & David Premack used a different method to teach Sarah (chimpanzee) to communicate by writing with magnetized plastic symbol [39]. All the word referring to object, person, action or related to comparison for instance were associated with specific unique magnet. The chimpanzee could communicate with the researchers placing the magnet on a support. One of the advantages was that the individual do not have to remember the question or the previous answer as the information could be visible on the support.

2.1.5. Other

Ann & David Premack developed another technique in which the ape has to use a joystick in order to generate the phonemes of English. This technic was two complicated and thus stopped [37].

2.2. Dolphins & California Sea Lion

Louis Herman and Ronald Schusterman used large-scale arm movments, signs (hand-shaped) and computer-generated sounds with bottlenose dolphins, Puka, Kea, Ake, Phoenix (*Tursiops truncates*). The animals had to associate specific (artificial) whistles with objects and/or actions. Dolphins were asked also to use (press on) dedicated paddle [40,41]. Scientists used command gestures to teach Californian sea lion (*Zalophus californianus*), Bertie and Rocky, names and characteristics of objects [42-44].

2.3. African Grey Parrots

In the 70s Irene Pepperberg started her work with Alex, an African grey parrot [45]. She used the Model/Rival technique in order to English words to the bird. In this method, two persons interact in front of the bird and take successively the role of the trainer—asking for the name or characteristic of an object and the student—that represents the model while answering correctly. In this situation, the student represents also a rival for the bird because he gets the trainer' attention and receive the reward (object or food) if the label was correct-corresponding to the question. Humans exchange their role and sometimes ask directly to the bird for the correct answer [14]. The Human student also produces sometimes incorrect answer so that the bird can see that not all the sounds have the same meanings and that the trainer is expecting for a specific (referential) label. Several birds were trained by Irene Pepperberg and currently Griffin is still learning more words and concepts [46]. Other laboratory decided to work on language-trained parrot, in France [47,48], Czech Republic [48] or Canada [49]. Different methods have tested in which several parameters were changed such as the number or the nature of the trainers [50], the social interaction [51,52], the referentiallity [48], the joint attention [53], the use of video [54, 55] or sound [48] records, etc. The results vary according the birds (sex, age, personality, cognitive ability, vocal competencies, motivation) and their social environment [46,48]. Most of the bird learned rapidly new words but some of them had difficulties to associate to an object or a characteristic.

2.4. Dog

More recently a Portuguese team starts to train a dog to use a keyboard in order to ask for food, a walk or to be petted [56]. A female mongrel dog named Sofia, was submitted to a training program in which she acquired the discrimination of lexigrams associated to specific desires and the use of a keyboard to produce requests. The authors make sure about the motivational state of the animal (intention) and the communicative nature of the interactions (perspective taking; [57]). The authors report that the dog learn quickly to use the device when experimenter could see the information. They observed some modifications in the behavioral display before and after keyboard pressing suggesting a certain arousal for specific needs [56].

In general, all the individuals (whatever species they belong to) have (had) a good understanding of human language (English, French, Portuguese, etc.) [48,56,58].

3. Achievements

Possession of (or the ability to acquire) human language or at least some form of a human-based communication code has been posited as a necessary precondition for an organism to organize and process information for certain complex cognitive tasks. Language may help to have abstract representation even if it's not absolute pre-request as human infants, for instance, could have difficulties label object but not to classify them in same/different categories. Language may reveal inherent abilities rather than enable animal to learn more complex tasks even if animal that have been trained to use human-based language code do better than untrained animals on some tests such as those requiring understanding of analogies, but not for task of spatial representation [39].

3.1. Animal Acquisition of Human Based Communicative System

Apes signed and used plastic magnet and lexigram to ask for toys, food, etc., but also for walk and interactions. In few occasions they described their environment [59,60]. Alex learned and use English labels to answer the questions but also to ask for something. Sometimes he even asks questions about objects characteristics or name [46]. Dolphins learned to mimics specific sounds, used to designed specific objects. [41]. The Sea lion was able to associate the different gestures with specific meaning such as object' name, actions or even object characteristic [43]. Loulis (chimpanzee) learned to sign for several different categories such as people name, objects, actions, location. He also displays "No" or "Want" signs [61]. Apes and parrots learn different categories such as "color of", "name of", "size of", etc. [37].

Sofia's performances at the keyboard was based on the association of a specific sign with a specific desire and that it was part of goal directed sequences similar to those normally displayed by dogs. The dog does not use it when alone, presses in view of the experimenter [57] and alternates gazing between the experimenter and the object.

The apes species, dolphins and grey parrot show evidence of both discrete combinatory and category-based rules. The dolphins and Kanzi show knowledge of argument structure (although for Kanzi, only in his comprehension of English). The capacities that underlie these three properties of syntax, then, do not appear uniquely human [62]. Referentiality and syntax have been also demonstrated with other apes. Sherman and Austin (two chimpanzees using lexigrams) show some understanding of the different category "food" vs "tool", and classify the objects, their pictures or even their corresponding lexigrams. [37] Lana learned to chain lexigrams into strings that were similar to human sentences. Heidi Lyn showed that the vocabulary errors produced during ten-year data collecting period for Kanzi and Pabanisha revealed that apes are able spontaneously to create a complex, hierarchical, web of representations when exposed to a symbol system (lexigrams) [63]. The Californian sea lion show some understanding of semantic [42]. Sofia has been able to extract the information contained in complex messages and to integrate it in directed performance. In a recent study Sofia responds to verbal requests composed of two independent terms, one referring to an object and the other to an action to be performed relative to the object [64]. Nevertheless, when looking at word comprehension in other dogs, we can see that Rico (border collie) discriminate dozens of words and showed a "fast-mapping'' performance similar to children's, that is, the capacity of attributing, by exclusion, a new word to an object never seen before [22] and Chaser, another border collie [65], comprehends object names as verbal referents (more than a thousand words). Of course dogs never learned to say any of the words they learned (understand). In this respect, their limited vocal production and extensive comprehension are similar to those of human-trained sea lions [42], and dolphins [66]. Apes are also limited regarding their vocal ability but they have a quite good understanding of human words and are able to map new words onto new object (fast mapping) in ostensive context like dogs [67]. Alex also displayed fast-mapping [68].

Most of the individuals (apes and parrots) have been observed while babbling. Some individuals also recombine phonemes or sign or even create new ones (e.g. Washoe created a sign for "bib") [69,70]. These are some example of combination: "ring-ball" combination of bottlenose dolphins [71] while playing with both toys at the same time, Washoe sign "water bird" for swan or "cry hurt food" for radish; Lana press the lexigrams "Coke which is orange" for Fanta [72], Koko sign "White tiger" for zebra; Alex: "green nut" for pumpkin seeds, "banerry" for apple [46].

Animals have been also observed "talking" to themselves [38,73]. This occurred during the learning and consolidation phase but not only. Indeed, parrots enjoy these moments (resting period). They can also "talk" to describe their environment or express what they have to do (e.g. Washoe signed "Quiet" when she sneaked into a forbidden room [38].

3.2. Individuals Understand Concepts

Dolphins can label things and report presence or absent of such object by pressing on specific paddles [17].

Alex was trained on absence of a difference or similarity "what same?/what different?", as well as apes. Thus individuals were able to display a zero-like concept—which is the expression of an absence of something (e.g. no difference or none green block) [46]. Not only Sarah mastered the concept of same and different (e.g. apple different banana) but also was able to judge the relationship between relationships, a higher order of conceptualization (e.g. pairs of apple similar pairs of bananas but different an apple and a banana). Sarah learned the concept of "name of", "color of", she also mastered conditional "if-then" [39]. Lana learned to use "more" and "less". Alex also was able to compare quantity based on Arabic numerals or sets of objects or to compare the size of two objects. Sea lions were able to mastered comparative and absolute size comprehension in the Sea lion [43] (See the categorization section above for birds examples).

Kanzi, Panbanisha and Panpanzee used precursor of morality while pressing the lexigrams "good" and "bad" in appropriate contexts. This suggests a symbolic language processing in the different species but heavily influenced by the value judgments of their human caregivers [74].

3.3. Categorization

The ability to categorize elements of the environment, *i.e.* to classify objects according to proprieties they share, is a fundamental aspect of information processing. Conceptual categorization implies two criteria: a rapid generalization over class members of items and a classification of items not necessarily similar perceptually (e.g. "food" vs "tool" items [75,76]). Alex, was able to categorize items according to their color, shape or matter. He was capable of giving the similar and/or different characteristics of the items presented [77,78]. He was also able to identify the number of items according to two modalities [79,80]. Alex's categorization was noteworthy because he expressed this classification by verbalizing labels. However, Alex received a long training (months to years for various items and/or concepts) before being able to label and categorize correctly the items presented. In a recent study two African grey parrots learning French labels spontaneously categorized items with vocal imitations [48]. At the time of the experiment, the birds knew a few referential labels belonging to two different classes (food and objects) and imitated several labels that did not refer to particular items. Although we were trying to teach them new words, we observed that both subjects tried to say some other labels that they knew in order to obtain the items presented. The unexpected result was that, although never rewarded for this behavior since they did not use the labels corresponding to the items shown to them, both individual spontaneously emitted more "food labels" in front of food items and the male produced more "object labels" in front of object items [47]. Note that labels of a given category (*i.e.* either food or object labels) do not share common acoustic or visual features. Thus, the parrots spontaneously attributed a class to their vocalizations according to the edibility of the items presented (food or object items). This ability is similar to that described in macaques able to distinguish food vs non-food items [81]. Such an untrained categorization is rarely described in animals, but it could be related to a mechanism commonly observed in human children learning to talk. During the acquisition of the meaning of words, children generally adopt two different strategies: over-extension and under-extension [82]. The latter consists of using different labels for the same item. The over-extension strategy consists of attributing one label to different items. In children, over-extension usually is a process associated with perceptual categorization. Overextension gradually disappears when children add features to a word such as its functional role [83]. In the case of parrots, it seems that they used something like the over-extension strategy, by using a few food labels to ask for all food items and a few object labels for all object items. This type of error in the mechanism of information treatment was also observed in language-trained apes [38,63]. Pepperberg, without having formerly tested categorization with her parrots, reports that when Alex erred on, for example, a color label for objects, he most often provided another color label [46,77].

3.4. Numerical Competencies and Optical Illusion

Furthermore, Alex spontaneously established equivalency relations between Arabic numerals and the corresponding sets of items [84]. Alex learned to quantify sets of objects with vocal labels [79], choose the set corres ponding to the vocal number label [80], utter the corres ponding number label in response to the presentation of the number symbol and to select the number corresponding to the vocal number label [85]. Griffin is currently tested on visual perception. He already knows some colors, shapes and numbers. Irene Pepperberg is currently addressing the following question: Are you still seeing a square even when one of its corners is overlapped by a masking object? Yes, it seems that the bird perceive the object as complete structure. Maybe grey parrots are able to represent mentally the "normal" image of a square. Alex had been tested on the Müller-Lyer illusion [86] and the results suggest that like humans, birds are sensitive to optical illusion.

A bottlenose dolphin discriminates visual stimuli differing in numerosity [87]. Apes have been tested on their numerical competencies and their ability to compare quantities using items or symbolic representations (object or lexigrams). Symbolic representations help chimpanzees to succeed in a reversed reinforcement contingency task. They maximize reward choosing the smaller Arabic number (and thus receiving the larger quantity of reward) but failed to do so when facing the food item [88].

3.5. Transmission of the Communicative System among Conspecific

Kanzi learned through observation (of the adult) how to use lexigram. Loulis (Washoe was his foster mother) was not cross-fostered and learn through interaction with the other chimpanzee to sign. Loulis mastered sign language through watching, babbling and then doing the sign properly [89]. The researchers also observed maternal hand-guidance as Washoe molded Loulis's hand into the sign for "food", or place "drink" on his lips. Several times Washoe sign the name of object in front of Loulis and before using them such as "brush", "hat", etc. Washoe also learn new sign from her conspecific such as "blanket" for instance [38].

The same for birds who learn from each other new vocalization and thus new words and then associate the label with the correct object (or characteristic). Irene Pepperberg reports also that Alex vocalized several times "say better" or even giving the (right) answer when another birds was questioned [46].

Using lexigrams, words or plastic object is also a good way to assess the memory of an individual across the time. Thus Lana, Koko, Kanzi *et al.* remember the name of object they did not see for several months [37,90].

3.6. Expression of Feelings, Expectations, Pleasure or Frustrations

Irene Pepperberg, taught to employ the vocalization "want" before an object label so as to discriminate functional "labeling" from "requesting" [91]. Thus When Alex was asking "What toy?" even if he was not motivated to play with it he could have ask for a nut after having gave the right answer. Indeed, Shango (African grey parrot) who was at the beginning of French word acquisition, stopped rapidly to say "semoule" ("cornmeal") because he did not like the taste of the corresponding food [48]. Alex was requesting for a reward (want nut) but also to stop the session ("wanna go back/ wanna go chair"), or vocalized when he disagree saying "No" [46]. Cabanac, who trained Aristote (African grey parrot) with the Model/Rival technique, observed that his bird was able to combine labels that express preference and pleasure. Indeed, the bird was taught with different labels and when the experimenter was interacting with the birds he pronounced specifics words such as "bon X" ("good X") when given the object X or doing some actions (such as preening) the birds just ask for. Latter on the author observed that while he was giving a grape to Aristote, the bird spontaneously pronounce "raisin bon" ("good grappe"), a label combination he never heard before [49].

In the same way, apes using lexigram or sign language requested for food, toy, tickles, etc using the appropriate signal and also request for "more" or "less" of it. Washoe sign "More" to get more tickling after that the Gardners introduced "More" into a game of pulling [38].

3.7. Animal Used Artificial Communicative System as a Tool

Four African grey parrots have been tested on their ability to obtain an item suspended from a string such that multiple, repeated, coordinated beak-foot actions were required for success. Only the birds with little training in referential English requests (e.g. "want X") succeeded. The two others (Alex & Griffin) failed to obtain the reward as they did not try and engaged in repeated requesting "want nut" [92]. Even if their intentions were not to manipulate humans' behavior at least the birds understand the usefulness of the vocalization and its use within a heterospecific communicative system.

The African grey parrots tested in the French laboratory developed specific asking calls for food [93] but they never used it during the test sessions and on the contrary labeled differently the items according to their category (food vs toy) [48].

Apes signed, pressed lexigram or combined object in order to request for food or toy or whatever. In captivity, Chimpanzees have been observed to beg extending an open hand and vocalizing. Loulis for instance produced the sign "Gimme" to request for a preferred food [89].

4. Conclusions

Several individuals of very few species have been involved in language-trained studies. Mostly primates but also other mammals such as dolphins, sea lion or dogs and one bird species, the grey parrot. The different experiments have more or less successful according to the technique used (e.g. joystick vs ASL) but also to the individuals [37].

All these studies provide astonishing results for the scientific community. Animal species are able to comprehend and produce part of a communicative system and able to understand new utterance. The gap between human and non-human species is smaller than expected. These studies have changed the perception humans had from the rest of animal species. Even animals with a brain of the size of a walnut (grey parrots) manage to learn words and describe the characteristics of objects according several modality and also to elaborate complex concept. All the data collected change the way animal consciousness was perceived by humans. This have a direct impact on animal right and the laws for animal welfare.

The different individuals tested have shown complex and diverse competencies. Thanks to the different artificial language systems, the researchers manage to interact directly with the animals and thus access to a part of their own world.

All the experiments presented have raised many questions and critics among the community; critics about the methods used, about the number of animal or the influence of human on the animals' answers and also the way to validate or not new acquired "word". Some studies raised also ethic and welfare issues (e.g. activists had released dolphins in ocean) sometimes because of the housing conditions or the difficulty for the animal to adapt a life with conspecific later on (for apes for example). For instance Washoe, sign "black bugs" to designnate conspecifics (seen for the first time) [94]. Working in close proximity every day for several years with these animals leads to the establishment of strong bonds between experimenters and subjects-humans and animals [95].

The different experiments presented are complex because it takes time to teach animals a new code of communication but also because the results obtained (when obtained), come from only one individual (of one species). This type of study is also costly and time consuming. Most of the species tested are long-living animal species, some of them could be very aggressive or at least represent a danger for human because of their strength. Several people involved in apes studies lost one or more fingers. Thus the dogs—as tested in the recent study—seemed to be a good compromise between all these constrains and the advantages to be able to share a communicative system.

Some individuals had (have) incredible cognitive abilities. For instance Kanzi is able to communicate using lexigram, vocal production and sign language. He also demonstrates a great ability in using tool (motor imitation) [96]. Some individuals show some sense of time. For instance Nyota uses "yesterday" and "today" or Tatu who had a good sense of time, and knew that Christmas followed Thanksgiving [97]. Individuals express also empathy, comfort, or deception. They can inform the experimenter about something in their environment but can also lie to avoid punishment. They express their feeling such as the joy, embarrassment or the sadness signing or pressing key "happy", "angry", "smile", "cry", "hurt", etc. [97].

Scientist would now look to see if this new communicative system is used between individuals and across generations. The scientific community would tend to look to more accessible species such as dog which are already living in human houses! Thus not only we can know (or guess) what an animal think or feel watching its behaviors, social interactions and reactions (in decision making), we can study their ecology to have a better understanding on their natural communicative system but most importantly we can also develop an artificial communicative system to be share with other animal species in order to access the "black box". Nevertheless the issue of human interpretation still exists even with the artificial communicative system.

All these experiments had also brought information about the roots and the evolution of human language, even if some results are still controversy but more importantly raised other questions such as semantic aspect of the signals sequence.

Though useful information might lie in the "collected data" (animal mind), extracting them into insightful knowledge with human-accessible form (clear meaning, no interpretation) presents a demanding and sophisticated undertaking. Using a human designed language represent a window at the "black box". The different techniques developed lead to increase our knowledge on how animals perceive the world. Through the different examples presented, we have seen that the individuals (whatever was the species) organized their knowledge and develop strategy in order to solve the problem the experimenter were giving them (mostly answering questions). Scientist look at how animals learns, used and also their errors in order to access the way they are processing information.

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