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Abduction in Animal Minds

<https://doi.org/10.1515/krt-2023-0015>

Received May 26, 2023; accepted December 2, 2023; published online December 20, 2023

Abstract: Following ideas of Ch. S. Peirce on continuity of mind (synechism) and universality of semiotic processes (pansemiotism) as well as development of the understanding of manipulative abduction in works of L. Magnani the thesis of possibility of abductive reasoning in non-human animal minds is defended. The animal capacity to form explanatory hypotheses is demonstrated by instances of grasping regularities in environment, behavior of conspecifics and even self-knowledge. In the framework of debate on instinctual or rather inferential nature of abductive capacity questions of innate and acquired mechanisms of learning, the role of language in development of explanations and priority of inner (emotional) or outer (referential) perspectives in genesis of first explanatory hypotheses are considered.

Keywords: Peirce; abductive reasoning; animal cognition; manipulative abduction

1 Introduction

The relevance of the research on abductive reasoning in non-human animals (hereafter – animals) is prompted by wider discussion on realization of patterns of deductive, inductive and abductive reasoning in non-human minds including natural as well as artificial intelligence.

During this paper abduction will be understood primarily in the sense that was given by the founder of pragmatism, logician, mathematician and philosopher Charles Sanders Peirce (1839–1914), so as an autonomous class of reasoning and not as deductive error or Bayesian inference to the best explanatory hypothesis. Also, as far as abduction is defined by Peirce as “the process of forming an explanatory hypothesis” (Peirce 1931–1958, CP 5.171¹), the following consideration will concern questions of nature of explanation, namely is it an imminently inferential activity, its (in-)dependence of language capacity and symbolic representation, its relation to

1 The standard pagination for Collected Papers of Ch.S. Peirce indicated volume.paragraph.

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ontic categories and different types of knowledge, namely self-knowledge, knowledge of others and knowledge of environment. Surely, the task is to show what the evidence for the thesis that “non-human beings could generate new explanatory hypotheses” (Vitti-Rodrigues and Emmeche 2017, 303) is.

The paper examines the philosophical background that enables research on animal abductive reasoning; the instinct/inference dichotomy in definitions of abduction; some modern interpretation of Peircean definitions adopted to research on animal cognition; the results of research on animal abductive cognition and comparison of realization of abductive capacity in humans and other species.

The significance of the research is in outline of underlying issues of common roots of abductive capacity in human and non-human animals, be it connected with either pre-linguistic reasoning, or imitation mechanisms. The comparative perspective will also explicate some further directions of research on abductive capacity in such unusual fields as music understanding and hypothetical reasoning on protolanguage.

2 Philosophical Presuppositions

Peircean philosophy is deeply grounded in evolutionary way of thinking. As da Silveira and Gonzalez (2014) summarize the views of Peirce, “the universe is in a non-mechanical process of continual expansion, acquiring and modifying habits ... the cosmos is conceived as a self-organizing semiotic process structured by a continuous flow of information available to all existent” (153–154). The non-mechanical character of the process is covered in three doctrines of Peirce, namely synechism (“tendency of philosophical thought which insists upon the idea of continuity” CP 6.169), tychism (“the doctrine that absolute chance is a factor of the universe” CP 6.201), agapism (“the adoption of certain mental tendencies ... by an immediate attraction for the idea itself, whose nature is divined before the mind possesses it, by the power of sympathy” (CP 6.307)).

Each of the three doctrines has deep consequences in the study of animal cognition. Firstly, a highly metaphysical Schellingian synechistic outlook that “matter is effete mind” (CP 6.25), “merely mind hidebound with habits” (CP 6.158) states the continuum-view of mind that encompasses inorganic and organic matter, so denies the privileges of humans and priority of thought-having (“it is we that are in thought, rather than thought in any of us” CP 8.256). So, evolution can be described as a process of habit acquisition, adaptation and change, where organisms seek for stable habits that provide directions as well as constraints in development (ibid.). Magnani (2011, 153, fn8) indicates that the setting of synechism is natural for all biologists since Darwin notes on mental life and conscious actions of earthworms.

The synechism is closely connected to pansemiotism (the term of Nöth 2019, 151), the view of continuous semiotic process and links of all signs (“there can be no isolated sign” (CP 4.551)), where “man is a sign” (CP 5.314) and “mind may ... be roughly defined as a sign-creator in connection with a reaction-machine” (Peirce 1967, MS² 318:18; Lane 2009, 21). Semiosis as the process of establishing connections between different objects in mediating signs covers living constitutions (e.g. social movements), living consciousness, the life, the power of growth of a plant (CP 6.455), turning of sunflowers towards the sun (CP 2.274). In its turn pansemiotism is related to the doctrine of ontological categories, namely Firstness, Secondness and Thirdness that, roughly speaking, can reflect the evolution of Universe (Absolute Chance, Habit Acquisition, Laws, respectively), psychological entities (Feeling, Action, Thought), state-description (Fact, Resistance, Mediation), types of signs (Icon, Index, Symbol) etc. Since Peirce acknowledges that “consciousness may mean any one of the three categories” (CP 8.256), the issue of presence of consciousness in animals is solved by the recognition of the obvious fact that animals can feel and react. The development of Thought, Thirdness in its ontological sense also emphasizes a highly inclusive approach to agency (CP 4.551). The Thought has ontological priority over thinking agents, but it also develops in the organic world (CP 4.551, CP 5.603).

Turning back to three evolutionary doctrines, tychistic involvement of chance in the world of natural necessity provides variability. In this framework abduction is one of the instruments to handle oscillations of novelty and anomalies. More speculatively, the qualitative leaps in development of mind among various species are also tychistic.

The agapistic approach postulates the need for cooperation as far as “every logical evolution of thought should be dialogic” (CP 4.551). The Peircean approach to evolution may be assessed as more in the spirit of P.A. Kropotkin rather than Darwinian with emphasis on cooperation, information sharing and development of complexity rather than struggle for survival. So, the inner dialogue, the dialogue of conspecifics, dialogue of cultures and all cooperative efforts to search for understanding are instances of agapism. The goals of agapistic behavior in the evolution of the Universe are liberty and making “life more reasonable” (CP 1.602). Surely, the respectful and less anthropocentric attitude to other species, especially in studies of their cognitive abilities, is also an application of agapism.

Yet another crucial feature of agapism is the thesis that the human mind is in harmony with the Universal Thought process, so this harmony justifies the feeling of analogy and epistemological optimism that universe can be knowable (CP 1.316), therefore abductive capacity of animals is also knowable.

2 The standard pagination for Manuscripts of Ch.S. Peirce (MS page).

The application of Peircean semiotics to anthropology (Kohn 2013) gave the language of description for the non-symbolic interactions (through icons, e.g. the pungent whiff of cinnamon from wild passion fruit and indices, e.g. the sound of crashing palm is frightening index for monkey forcing to notice something happened, focus attention and move) occurring in world of living semiotic selves. The mediation of signs in this context is presented as a form of communication that is free from anthropocentric language bias, but is attentive to spontaneity, growth of signs and constant mutations of perception-thought-action-habit. The life signs are claimed to be beyond the human. So, the metaphysically-laden semiotic view of life serves as a methodological tool in anthropology for escape from dualistic ontology dividing the world on human and non-human. However, the question is still open what the naturalistic grounding for the claim that animals can abduce is.

3 Definitions of Abduction in Use

As far as the multitude of papers and drafts of Peirce relate to the issue of the determination of definition, role and functions of abduction, the working definition in studies of animal abductive reasoning should be indicated.

Firstly, one of the most known notions should be mentioned, because it is presented in form of inference and includes the encounter of anomalous experience (CP 5.189).

A surprising fact, C, is observed.
 But if H were true, C would be a matter of course.
 Hence, there is reason to suspect that H is true

Surely, abductive inference is the weakest type of reasoning in comparison to deductive and inductive inference with its expectability against their necessity and probability (CP 5.194), "... nevertheless is logical inference ... having a perfect logical form" (CP 5.188). However, inferential essence is understood broadly: "... every state of consciousness [is] an inference; so that life is but a sequence of inferences or a train of thought" (CP 7.583).

Secondly, it should be noted that some philosophers of science and logicians distinguish selective and creative senses of abduction, where the first one is also known as inference to the best explanation.

Abduction is also connected with the topic of explanatory virtues, because correct evaluation of hypotheses is in need even there is only one proposed. Among the requirements for hypothesis Peirce identifies verifiability (CP 5.597; CP 5.189), simplicity (in sense of Ockham's razor CP 5.26), economy of research ("how, with a

given expenditure of money, time, and energy, to obtain the most valuable addition to our knowledge” CP 7.140; CP 5.602). However, the whole range of ethical, esthetical and economic norms is significant in the inquiry. In words of Peirce, good explanatory hypothesis fulfills its end when it after the test can “lead to the avoidance of all surprise (CP 5.197). It seems that general considerations of usage of limited resources is in framework of evolutionary logic, so it is easy to hypothesize that animals in some way or other implicitly assess hypotheses by these criteria.

Abduction is strongly connected with pragmatism (CP 5.196), so according to maxims of pragmatism the elaboration of explanatory hypotheses should take into account the effects of conceptions (CP 5.195–200). It is a very valuable methodological instruction for parsing meaning in animal behavior: whatever the agent means will be explicable in new habits and actions after the contact with surprising experience, “a possible difference of practice” (CP 5.400).

Magnani develops further distinctions in abductive reasoning and circumscribes (2009, 41–42, 60–61, 2011) the familiar verbal/symbolic inferential forms of abduction as sentential and separates them from model-based abductions that can operate with tacit information inaccessible on propositional level, but accessible through the exploitation of internal models or manipulation of external models of pictures, diagrams, maps, social relations, context (2009, fn 51). Magnani highlights that abduction is multimodal, so it has various kinds of representations including smells, kinesthetic information, resources of imagistic and analogical reasoning. Manipulative abduction (usually model-based, 2009, 58, but also action-based *ibid.*, 48) is understood as “a large part of scientific thinking where the role of action is central ... action can provide otherwise unavailable information that enables the agent to solve problems by starting and by performing a suitable abductive process of generation or selection of hypotheses” (*ibid.* 12). Manipulative abduction is embodied in individuals and broader “into the whole relationship between our mind-body system and suitable external representations” (*ibid.*, 46). As it is rooted in practice, manipulative abduction can be translated by imitation, namely watching and doing as in template. In general, manipulative abduction is preparatory for conceptual formulation, theoretical abductions involving narratives. In research on animal abduction exactly the notion of manipulative abduction is the most frequently used.

To sum up, although there is a great amount of notions of abduction, the discussion on animal abduction refers to such cues, as evolutionary embedded mechanisms of evaluation of hypotheses on environment; the striving for explanation of anomalous experience in order to dampen anxiety, take actions and refine the model of reality by attainment of hypothesis; usage of manipulative abductions.

And last but not least it should not be omitted that explanatory (abductive) tasks are not limited to scientific reasoning (discovery of patterns, laws, causal links), but

also includes diagnostic reasoning (guessing from symptom to illness), legal reasoning (establishment of the chain of events from evidence), engineering thinking (the reason for the break of the machine), and social interaction (understanding of others by attributing emotions, beliefs and intentions). So, humans trying to reveal the abductive capacity of animals often make experiments in such a way that studied animals have to disclose either causal thinking in manipulations with objects or social thinking.

4 Instinct/Inference Dichotomy

When Peirce writes on creative power of abduction, he constantly underlines the miraculous fact that history of science is full of successful guesses (CP 7.219). Humans as species are very lucky in their formation of hypotheses (CP 2.749), because among millions of possible hypotheses they often choose very plausible hypotheses. Peirce conjectures that humans have a natural adaptation, power of guessing as aeronautic faculty of birds (CP 7.48) that is why Peirce concludes that “all human knowledge, up to the highest flights of science, is but the development of our inborn animal instincts” (CP 2.754). Thus, Peirce acknowledges that abduction has instinctual and inferential components.

Instinct is defined by Peirce as “generalization of abstractions” (Peirce 1998, EP³2: 473) referring to the commonalities in response to stimuli in one species, although voluntary this response may be, but with important effects of behavior on future success of the species representatives. The possession of abductive instinct is a question of survival (CP 5.603). Peirce notices that instincts can be erroneous, can change and can be modified to the better through learning. Instinct is an inherited disposition/habit, where habit is defined as “general principle working in a man’s nature to determine how he will act” (CP 2.170).

Reason is “a sort of instinct” (EP2:472), while intellect is “the meaning of any representation in any kind of cognition, virtual, symbolic, or whatever it may be” (EP 2: 226–227). Reasoning is described as transfer from known truth to novel truth which can be realized instinctually, habitually with the necessary final stage of self-critical evaluation according to general rule (CP 4.476).

In some sense Peirce anticipates the distinction of System 1 and System 2, because he delineates (MS 832, 1; Nöth 2019, 150) instinct as fast, subtle enough and effective enough system (recalling System 1 descriptions) and reason as superior system in aspect of its capacity to self-control and revision of beliefs (similar to System 2) taking into account that “self-control of any kind is purely inhibitory. It

3 The standard pagination for the collection of papers Essential Peirce (volume:page).

originates nothing” (CP 5.194). Instinct surpasses reason “directing us as if we were in possession of facts that are entirely beyond the reach of our senses” (CP 5.173), instinct helps to choose the best explanation due to simplicity. Reason also encompasses the field of moral self-control and esthetic ideals of fine, but for current purposes the other remark may be more illustrative, namely the recursive structure of hierarchy in self-control (“exercise a control over his control of control ... it seems to me that our superiority ... is more due to our greater number of grades of self-control” (CP 5.533)). However, as Peirce states, “every phenomenon of our mental life is more or less like a cognition” (CP 1.376), so the Peircean account can be interpreted as development of critical but not creative capacity on the productive ground of instinct as well as expansive sense of cognition that encompasses perception, volition, emotions. Reason can be also presented as the highest level of recognition: “every kind of consciousness enters into cognition” (CP 1.381). The hierarchical structure is comparable to syntactic structure of language and Peirce mentions both these capacities nearly in the text (“By a “person,” by the way, I suppose we mean an animal that has command of some syntactical language ... a person as an animal possessed of moral self-control” (MS 659: 10–11; Lane 2009, 21)).

Peirce compares the human instinctive power to guess correctly with instincts of other animals and draws many conclusions from this analogy. Firstly, instinctive capacity to guess correctly is connected with efficiency of actions, evolutionary success. Secondly, as in case of animals, this capacity is innate, otherwise faculty of thinking would not save the organism as it takes time (Peirce suggests an instance of chicken that orients fast after being hatched and starts pecking by instinct, not by inferring). Thirdly, the instinct is itself as in the example of chicken “innate tendency toward a positive truth” (CP 5.591), where positive is understood in the sense of not being reducible to logical formulas (CP 5.496). Peirce also tries to disillusion the anthropocentric point of view downplaying the priority of reason in human life, as when he states that most time humans are in the captivity of habits, associations, instinctive reflection, not fully rational inferring (CP 7.606).

Like humans, animals are bearers of Firstness (sensations, feeling of pain and pleasure), Secondness (body that acts and reacts), Thirdness (communication due to training as in case of domestic birds and animals, reaction to music and speech, CP 7.585, CP 1.314).

Peirce concedes that animals do reason, “if by Reasoning be meant any mental operation which from the putting together of two believed facts leads to a Belief different in substance from either of those two” (MS 672, II.1–2; Nöth 2019, 142). In other places Peirce connects learning, adaptation and creation of new strategies in living, constructing and foraging with reasoning insofar as animals demonstrate self-criticism (MS 831, 12–13”; Nöth 2019, 146).

Thus, Peircean interest in the dichotomy of instinct and inference is a human-centered perspective on a combination of old evolutionary and consciously developed programs in modern humans that are effective in self-control as well as scientific reasoning. However, the perspective of contemporary followers of Peirce is animal-centered.

Nevertheless, not all scholars recognizing the primary role of abductive reasoning in evolution of human scientific reasoning and its tight connections with instincts also acknowledge the buds of abductive reasoning in animals. For example, Ratajczyk (2017), states that instinct is tied with a narrow complex of issues, while reason provides diversity of possible solutions and plasticity beyond natural specialization. So, for the author abductive reasoning is the exclusively human capacity due to associated creativity and cognitive flexibility. He neglects evidence⁴ that chimpanzees, rats, mice and corvids use deductive and inductive reasoning so there are chances that they are capable of abductions. In addition, as scholar states, the emergence of abductive reasoning is the result of strategies of food foraging applied by hunter-gatherers that had to construct models of behavior of the prey, analyze the signs (traces, vocalizations, movement patterns) and also result of cultural evolution (especially, consideration of afterlife, so creation of beliefs). Thus, hominids created explanatory hypotheses not only about surrounding reality, but also transcendent reality and surely, there are yet no cultural testimonies of burial practice in other species.

Many scholars take into account Peircean broad definitions of inferential and sign activity to develop the representations of human abductive capacity.

Paavola (2005, 143, 147; CP 7.381 fn19) highlights such features of abductive instinct as fallibility, capacity to be advanced through learning, dependence on context, element of free play, partial control of reflection and imagination, processing of small clue-like signs.

Wheeler (2010) solves the dilemma of instinct and inference referring to the animal mind in human beings: “Peirce’s semiotic logic of abduction involves the recursive movement from human world into human animal world, into captivated enchanted musement, and then back again into the open” (ibid., 284). So, intuition and instinct operate as a pre-conscious study of inquiry, necessary and obligatory for further logical treatment of insights.

Colapietro (2014) writes that “our embodied minds frame and act on hypotheses as spontaneously as our lungs inhale and exhale” (ibid., 128), so he emphasizes the

⁴ Wass et al. (2012) show evidence for deductive and inductive reasoning of mice. Russell et al. (1996) summarize information on the capability of drawing deductive transitive inference of monkeys, pigeons, rats and chimpanzees. Sauce and Matzel (2017) enumerate examples of inductive reasoning of sea slugs, rodents, dogs, cats, chimpanzees, chicks, pigeons etc.

instinctual aspect of human abductive capacity. Due to expansive sense of abduction (“instinctual disposition . . . our innate tendency to generate experientially prompted guesses” *ibid.*), for Colapietro all human movements are “in effect conjectures” (*ibid.*) and experience develop human abductive skills.

Magnani (2010) argues that Peirce concentrates on innate capacities (“wired” cognition), though cognitive plasticity and adaptations to changing environments are abundant in the animal world. The semiotic activity of animals is model-based or inferential in just broadest sense (“not reduce the term “inference” to its sentential level, . . . but which includes the whole arena of sign activity all inference is a form of sign activity, where the word sign includes “feeling, image, conception, and other representation” (CP 5.283)” (*ibid.*, 231)), but anyway animals are real cognitive agents that generate hypotheses despite the fact their abductions are language-free. Magnani gives an example of developmental plasticity in plants (“developing tissues and organs “inform” the plant about their states and respond according to the signals and substrates they receive” (*ibid.*, 227)), it can be added that fungi use spikes of electrical activity to communicate and process information in mycelium networks (Adamatzky 2022). So, interestingly, plants, fungi and animals demonstrate the capacity to communicate the information about physiological state of communicative agents (functional hypotheses) and environment (causal hypotheses in most cases). Magnani highlights that the abductive capacity of animals is realized in the creative stage when organisms encounter surprising facts in experience as well as in the selective stage during the choice of actions. Magnani (2011) concludes that abduction is instinctual as well as intellectual capacity. The rationality of abduction is analyzed in terms of internal evaluation of appropriateness of particular behavior in terms of belief-desire-intention model; not only logico-epistemological ideal, but also heuristic thinking; search for optimal strategy and selection of hypotheses (from foraging to scientific inquiry). Magnani delineates the evolution of abduction in connection to verbal and model-based imagination, development of artifacts that in their turn enhance causal thinking and second-order thinking as thoughts on thoughts of others to understand conspecifics and manipulation with instruments for advancement of other instruments, namely the precursor of meta-thinking.

Thus, in contrast to Peirce modern scholars emphasize the role of embodied learning, operating with representations (manipulative abduction), spatial imaging, goal-directed behavior (that is a great help in understanding conditionals), analogical reasoning of animals, action-based abduction. As Magnani aphoristically put it, not only the language is an unnecessary condition for abductive thinking, “some organisms can learn and memorize even without the brain” (*ibid.*, 234).

5 Animal Abductive Capacity

Peirce did not doubt that non-human animals use signs, but, as he remarks, they do not reflect the sign nature and do not criticize their own thoughts logically. So, Peirce distinguishes as exclusively human such features as inner dialogue (CP 4.6), capacity to abstract, especially in mathematical reasoning (CP 5.534), syntactical language (MS 659:10–11; Lane 2009, 21) and higher degree of self-control (CP 5.533–34). However, as Darwin in famous quote on quantitative, not qualitative character of difference,⁵ Peirce notes that animals “certainly do not carry this control to anything like the same grade that we do” (CP 5.534), but the definite degree of self-control is nevertheless present.

Interestingly, Peircean remarks on being a person (inner dialogue) and thinking abstractly (more correctly, “operation ... when something, that one has thought about any subject, is itself made a subject of thought” CP 5.534) as distinctive features of human rational being became the object of constant research. Personhood, self-reference as well as syntactic hierarchical thinking are in the focus of discussion whether animals are capable of abductive reasoning. Although there is evidence that animals can offer explanatory hypotheses for internal, psychological, as well as external reality as humans can (CP 5.591).

Typically for Peircean philosophy, personhood can be realized in three-categorical ways. So, it is a well-established fact that mirror tests show that animals are capable of suggesting explanatory hypothesis for their identity in the mirror (Firstness of personhood). Surely, the experience of survival and learning is acceptable for animals, so they can abduce on world patterns (Secondness of personhood). Thirdness is realized in ultimate version of synechism in life of social insects, as far as they have as some groups of people (in club/university/company) collective personality, in other words esprit de corps (CP 6.307, 6.269–70, MS 961a: 87; Lane 2009, 14; de Waal 2006, 157).

This short overview is not exhaustive, so further on more elaborated studies will be enumerated taking into account that anthropomorphism is one of the most significant methodological obstacles in study of animal cognition, so each research group that explores abductive reasoning determines key concepts that allow them to conclude on the presence of abductions.

The research of Vitti-Rodrigues and Emmeche (2017) is made in the framework of problem-solving approach and semiotic concept of information. Intelligence is understood as the capacity to change habits to adjust to the environment, or in pragmatic terms, to generate new hypotheses (propositions) by gathering information.

⁵ “... the difference in mind between man and the higher animals, great as it is, is certainly one of degree and not of kind” (Darwin 1889/1981, 105).

Habit, according to Peirce (CP 5.538) “denotes such a specialization, original or acquired, of the nature of a man, or an animal, or a vine, or a crystallizable chemical substance, or anything else, that he or it will behave, or always tend to behave, in a way describable in general terms upon every occasion (or upon a considerable proportion of the occasions) that may present itself of a generally describable character”. Semiotic conception of information is described by Vitti-Rodrigues and Emmeche as sign action, namely “a process of conveyance of forms that consolidate meaningful organism-environment interactions” (2017, 296), where meaning in the pragmatic spirit of the sense of the term states for conceivable effects of objects in the future conduct. Abduction is posed as an informational process for establishment of beliefs that explain surprising facts and incorporate strange facts into a network of beliefs (ibid., 297) by deepening the interpretation of objects (ibid., 305). Technically, stages of abductive reasoning are enumerated as struggling with surprising fact of unpredictable property of object or strange relation, sign processing (through manipulations with objects), hypothesis (e.g. causal or structural) and behavioral adaptation. As authors note, even the process of interspecies interaction and mutual understanding is also a case of abductive reasoning (ibid., 301), so the research on animal cognition presupposes abductive position. Vitti-Rodrigues and Emmeche discuss the series of experiments on causal cognition with New Caledonian crows. Following the Aesop’s Fable “The Crow and the Pitcher” the task was to drop stones into water-filled tubes in order to be able to reach a reward while the modifications were the content of tubes (water/sand, high/low water level), material and properties of things to drop (sinking/floating; solid/hollow objects), the form of the tube (wide/narrow; U-form). Crows were efficient and successful enough in understanding the causal relations with focus on anomalies and taking feedback. Crows worked individually, so the resource of social cognition was not used. However, not a hundred percent of success may be clarified by such issues as lack of motivation and inconvenient design of experiment with neglect of the crows’ limitations of eyesight (in a task involving three tubes two of which were with hidden connection). In other paper (Vitti-Rodrigues and Emmeche 2021) scholars analyse the results of experiments on social cognition of ravens and explore the proof of the hypothesis that ravens do use Theory of mind, namely that they can understand the perspective of other organisms taking into account their experience accessible in memory and desires. Vitti-Rodrigues and Emmeche (2021) conclude that the research was successful instance of abductive reasoning and the hypothesis of the presence of theory of mind is simple in sense of explanatory virtue and is informationally broad (CP 2.407) also as well as it can be extended to other corvids. Thus, there is evidence that crows possess manipulative abduction, as for the production of social hypotheses (hypotheses of understanding of others) and its mechanism the jury is still out. Interestingly, the ascription of belief-desire psychology to animals is associated with necessity of linguistic capacity (Magnani 2010, 230–231), so production of explanatory

hypotheses of behavior of conspecifics, the issue of understanding in social cognition is a yet another fault line in discussion of abduction.

Park (2013) referring to the analysis of Avicenna's ideas on estimative faculty of animals concludes that already in medieval psychology and philosophy researchers ascribe to animals the faculty of understanding intentions of other animals as in cases of prey sensing the intentions of predator, mother feeling the needs of the baby etc. In other words, animals can abduce to hidden causes, non-sensible intentions. Looking at decision-making of animals in the framework of inferential activity means constructing models and instinctual reactivity designates ecological adaptability. Colapietro (2014, 142, fn30) following the ideas of James on life answering life in doubling smiles and embraces remarks that "the sense of a threatening or a beneficent being is one of our most rudimentary yet crucial abductive propensities".

Thus, scholars that endorse the Peircean approach agree that animals can make explanatory hypotheses on the environment by manipulative abductions and also that animals can abduce on behavior of other animals by complex system of ascription of intentions. The instinctive component is connected to perception and adaptation to the niche, while the inferential component is linked to understanding of conspecifics and instrument manipulation.

The critique of the attempts to explore whether animals can make abduction is connected with the strict requirements to the abductive inference.

The research of Oaksford (2008) is done in the framework of psychology of reasoning and analyzes traditional for the field conditional tasks with the aim to detect ability to recognize stimulus equivalence that is failed by even closest biological relatives-species of humans as chimpanzees. The scientist claims that language with its ability to generate endogenous stimuli (sounds) is significant for keeping in mind representations and rehearsing it that is in its turn necessary for learning predictive relations. For the author, abduction equals understanding of hidden causes, so he identifies abduction with reasoning to the causes by effects. According to Oaksford, the successes of rats or sea lions to deduce the cause from the effects does not demonstrate their ability to make abductive inferences, because they do not operate with the space of many possible causes due to the lack of language. So, Oaksford has even more requirements for abduction understood as inference to the best causal explanation. Surely, for proponents of animal abductive cognition the very reasoning from effect to cause is a relevant evidence for, but opponents focus on the lack of linguistic capacity and connected difficulties.

6 Further Directions of Research

As far as animals demonstrate nonlinguistic abductive reasoning, the research into non-linguistic (and not only manipulative) human abduction may be insightful.

For example music theorists (Oliveira et al. 2010) claim that understanding of music consists of emotions as well as grasping the meaning and order, it includes interaction of abduction (perceptual judgement, analysis of meaning-related aspect of musical listening through habit acquisition), induction (probabilistic perspective of schemes of development of melody) and deduction (subsumption under the rules of styles and genres). This abductive quasi-intellectual (“quasi-” because of often unconscious character) game of following the composer’s design of unfolding the structure consists of fulfilled expectations (that is the feeling of conceived pattern, in some sense explanatory part of the process) and frustrations (“surprising facts”) in development of musical form, so hypotheses are generated through listening. This process could be called cognitive processing, but affective reaction is an imminent part of music listening, so it can be called habit acquisition in a more accurate way to highlight the sameness of psychological processes. Surely, music listening is related to the practice of forming habits as far as preferred music compositions form norms for taste and each deviation requires some time for adaptation.

The issue of habituation-adaptation for music may be examined in season shifts of “fashion” in bird-singing. For example, the experiment design may include birds training for song-motives that dramatically or slightly differ from the natural standards to provide various mixtures of surprising and predictable. So, the task of the researchers will be to evaluate how female birds will react to novelty, and will they appreciate the game of familiar and novel. Although it is difficult to assess what sort of meaning is transferred in birdsongs, it will be easy enough for scientists as pragmatists to assess the consequences of songs and success of performers in the behavior of female audience, namely their choice of better singer. Certainly, this kind of abduction whether it is approved is equally inferential and instinctive, non-linguistic, but rule-following. The argument against titling it as abduction is the lack of explanandum, so the song is just a game of capacities, combination of surprising and classic without knowledge acquisition.

The research on roots of human language capacity may also be insightful, as Marcus and Fisher (2003, 261) note, “the machinery of language is likely to be the product of a mixture of evolutionary novelty and evolutionary recycling. In general, the way that new structures are built is by small (but sometimes significant) modifications of old machinery”. The capacity to provide explanatory hypotheses seems more fundamental than language capacity, but nevertheless language capacity itself may use and develop some underlying mechanism common to ancestors and even

the reference to understanding the order of music as non-linguistic abductive ability is not accidental. The similarities of abductive reasoning in music reception and language may be the trace of earlier identity of music and language capacity. Darwin (1889/1981; Ma, Fiveash, and Thompson 2019) hypothesized about protolanguage (termed “musical protolanguage” by Fitch 2006), namely common root of music and language that was an emotional signal system based on the imitation and modification of natural sounds. This system was divided on music and language to separate emotional and referential functionality, respectively.

Interestingly, modern science indirectly confirms Darwin’s guess. The first identified as involved in human speech and language development gene *FoxP2* (Webb and Zhang 2005) is also crucial for song learning by birds (Wohlgemuth, Adam, and Scharff 2014; Xiao et al. 2021), although this gene is found in similar form in rodents, fish and reptiles (Fisher 2019). Scientists proved the common neurobiological substrate of language and birdsong (Miyagawa, Arévalo, and Nóbrega 2022). Scholars admit that “Like language, song of many birds is learned by imitation of adult conspecifics” (Wohlgemuth, Adam, and Scharff 2014, 86). This reference to the imitation mechanism opens debates on the (un-)specificity of human language capacity, namely the presence of concrete module of language that should be distinguished from general intelligence. For example, Fisher and Scharff (2009, 173) enumerating commonalities of human language and birdsongs notice that “birds and humans vary the order and arrangement of vocal units (‘syllables’) in a rule-governed way, resulting in a rich variety of sequences ... the song of many birds ... is constrained by innate predispositions and guided by auditory feedback”, so implicitly they refer to the principle of compositionality and inner grammar of rules as if the language module is a legitimate hypothesis. However, explicitly it is denied: “human language can create infinite messages via a finite repertoire of sounds, can refer to objects, actions and thoughts, and is governed by complex rules that crucially affect meaning. There is (as yet) no evidence that any of these features exists in bird song” (ibid.). As a result, there is no clear conclusion whether imitation is based on inferential mechanism that presupposes the paradigm signal, expectations of the recipient and surprise in case of novelty/anomaly, in other words, training of inner pre-established reasoning mechanism or it is based on functioning of mirror neurons, empathy and physical manipulations. It should be taken into account that the latter possibility concerns the realizations of the mechanism of understanding by analogy with own embodied experience and social factors (Fisher and Scharff 2009, 173 noted that social factors are significant for song-learning by birds). Curiously, the structure of division of arguments for the role of imitation mechanism, namely either imitation of referential structure (e.g. “complex vocal control ... might have enhanced a parsing mechanism for syntactic constituency, hence for the

identification of hierarchic structures” (Miyagawa, Arévalo, and Nóbrega 2022)) or imitation of emotions copies the Darwin’s vision of two systems in protolanguage.

Scientists remark that the amino acid substitutions that differentiate the human form of the FOXP2 gene from that of chimpanzees occurred during the Upper Paleolithic, ~50,000 years ago also known as a period of a burst of creativity appearing in *Homo sapiens* (Lieberman 2009, 800). This is the great coincidence for “the only logical operation which introduces any new idea” (CP 5.171), as Peirce titled abduction.

However, musical protolanguage is not the only option; scholars in the field of biosemiotics (Ponzio 2007, 133) propose the hypothesis of gestural protolanguage that was mute. Surely, the gestural roots of language if proven is the testimony for the evolutionary primacy of manipulative abduction over sentential and more broadly for priority of motor activity in development not only of language but also reasoning. This hypothesis (firstly stated in Hewes (1973)) is partly maintained by evidence from neurobiology, morphology, developmental psychology and physical anthropology. Proponents of the hypothesis of gestural protolanguage put forward such arguments as higher development of gestures than vocalizations in apes; well-developed gestural communication before the first words in infants’ development (Bridgeman 2005); the meaning-ladenness of actions as inter-individually accessible resource for understanding behavior (Parisi et al. 2005); advantages of visual transfer information in comparison to vocal due to the continued secrecy in non-cooperative environment (Wacewicz and Żywiczyński 2008); presence of “mirror system” in both Broca’s zone and premotor area that is activated by execution and observation of manual actions ((Arbib 2005), so yet another argument for the significance of imitation mechanisms); the predominance of right-handedness in homo species associated with the left-cerebral dominance for vocalization that is characteristic for many species of frogs, birds, and mammals that are evidences for evolution of vocalized language from manual gestures (Corballis 2003). Among difficulties scholars indicate “modality transition problem”, namely the lack of explanation for the alteration from primarily visual to primarily vocal modality in gestural primacy hypothesis (Orzechowski, Wacewicz, and Żywiczyński 2016) that also highlights the semiotic issue of change from iconic visual manual interaction to “primarily vocal communication system in which the links between symbol and referent are for the most part arbitrary” (Woll 2014, 1). The main challenge is modality transition problem, so authors propose such solutions as echo phonology (“repertoire of mouth actions which are characterized by “echoing” on the mouth certain of the articulatory actions of the hands” Woll 2014, 1), independently evolving musicality (Killin 2017), the bodily mimesis hypothesis that presupposes the stage of volitional control of the body between gestural and spoken language (Zlatev 2014). In addition, the presence of modern sign languages that are relatively new and being a subsequent

stage of the development after speech, not after protosign language also requires comparison of first usage of vocal and sign languages. On the one hand, vocal language suffers from the dangers of predators listening, but it also makes possible night talks and communication at a distance. On the other hand, the development of gestural language is not connected with evolutionary risks for larynx (deaths that occur as a result of choking), risks alerting the prey during hunting and can be substituted to tactile version (Emmorey 2005). As in other lines of debates the here-and-now system of imitation, empathetic system of imitation by mirror neurons is opposed to the capacity that grounds hierarchical capacity of language. Bridgeman (2005) suggests that the latter function may perform primate planning mechanisms that provide capability for creating, storing, and executing plans for sequences of actions (e.g. in preparing and using tools) and then transformed to planning word sequences.

Thus, the landscape of possible directions of research is complicated. The question of common roots of abductive capacity may lead to the primacy of the mechanism of general intelligence, inferential thinking; the priority of the human symbolic language module; the commonalities of interaction with the environment in gestures and sounds or the crucial role of social interaction. Firstly, there may be a common inferential root of human language and birdsongs, the mechanism of determination of familiar, unfamiliar and rule-following. So, human and animal abduction may be rooted in pattern recognition, inferential activity that is embodied in visual and sound abduction thanks to which living beings recognize the objects. Secondly, the core of abductive capacity may be in its embodied character, manual manipulations, so in this way organisms acquire understanding of cause and effects, inner structure of objects, cyclic dependencies etc. that had influence on human language capacity especially compositionality principle as well as abductive reasoning. Thirdly, the ground of abductive capacity may be in imitation mechanism and empathy, so the basis for all explanations is explanatory hypotheses in social interaction.

7 Conclusion

To be a Peircean scholar or not, it is rather insightful to use Peircean intuition on the possibility of non-human abductive capacity as if it is true. It was demonstrated that animals are capable of suggesting explanatory hypotheses to identify themselves, operate with complex instruments in the environment and understand other animals. The instinctive abductive capacity is present in perceptual judgments, adaptation to the challenges of the environment that require swift reaction, while inferential abductive capacity is indicated in understanding of intentions, exploring

the environment. The comparative framework of humans and other animals poses questions on the common root of abductive capacity be it manipulative-motor capacity that helps to form later syntactic vision of blocks and hierarchy in language capacity, be it capacity to emotionally sympathize and understand by analogy, be it imitation mechanism that enables in evolution abstraction of patterns from duplicates. Inner (mirroring, empathetic-understanding) perspective of development of abductive capacity unites development of abductive reasoning with analogical reasoning, social intellect, emotional control, while external perspective connects spatial imaging, memory, planning, motor skills development and abduction.

Acknowledgments: I would like to thank for the feedback and very useful comments on this article two anonymous reviewers. I also would like to thank participants of the Salzburg Conference on young Analytic Philosophy 2023 for the discussion on the paper during the session on philosophy of science and organizers for the inspiring atmosphere. Moreover, I would like to thank Dr. Ahti Pietarinen and Dr. Angelina Bobrova for the discussions on biological aspects of abduction.

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