THE ROLE OF HAND AND TOOL-USE
IN
THE EVOLUTION OF HUMAN COGNITION

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ABSTRACT

THE ROLE OF HAND AND TOOL-USE IN THE EVOLUTION OF HUMAN COGNITION

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The hand is a defining element of the human kind which has been transformed during the evolutionary developments. The most important feature of the hand is the proficient tool-use. Two questions become central in the present work: has the dexterous hand changed the human mind and if so, in what ways?

Keywords: Human Hand, Tool-Use, Tool Manufacture, Space Perception

ÖZ

İNSAN ZİHNİNİN EVRİMİNDE ELİN VE ARAÇ KULLANMANIN ROLÜ

Yiğit, Duygu

M.A. Felsefe Bölümü

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El, evrimsel süreçler içerisinde dönüşüme uğramış, insanoğlunun tanımlayıcı bir parçasıdır. Elin en önemli özelliği yetkin araç kullanışıdır. Elinizdeki çalışmada iki soru merkezi yere sahiptir: Becerikli ellerimiz zihnin evrimine yol açtı mı, öyleyse hangi şekilde?

Anahtar Kelimeler: İnsan Eli, Araç kullanımı, Araç üretimi, Uzay Algısı

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To Ernesto

TABLE OF CONTENTS

CHAPTER 1

INTRODUCTION

The acclaimed movie *2001: A Space Odyssey* by Stanley Kubrick opens with a sequence that pictures the life of an early hominin tribe. The tribe is in conflict with another tribe of the same species. At one point, the tribe is presented with a black monolith to which they seem to approach with awe and admiration. The black monolith is, according to the critics, a symbol for reason that is acquired by the ancestors of humans at some point. Following that instance, a member of the tribe goes near remains of a skeleton of some large animal, pick up a bone and starts smashing the rest of the skeleton. Later, the bone is used by the individual hominid to fight the other group. At the end of the sequence, the individual throws the bone to the sky where the shot ends, nevertheless, to be followed by another shot picturing a spaceship in space. This is known to be a match-cut signifying not only that these two are both tools but also jump from one to the other is immediate. Once humans were able to make and use tools, their sailing in deep space followed inevitably.

The idea in the movie *2001* was by no means an original one. Many philosophers have suspected of possible relevance between human reason and human hand and its tool-use, and even human language; although, genuine philosophical inquiries into the topic are quite rare. We are seldom aware of the miracles that we realize by the use of our hands and reason. In a blink of an eye in evolutionary history, we made an immense development in technology -from the hand axe to the particle accelerator.

Anaxagoras and Aristotle are the first known thinkers to mention a relation between the hand and the mind. While Anaxagoras holds that human beings are possessive of "intelligence" and they *think* because they have hands as he states in his *Fragments* and *On Nature* respectively, Aristotle contends that view by reversing the logic: humans are capable of using their hands because they are intelligent. (Radman, 186) Since theory of evolution was by no means a popular idea back then, it is understandable why Aristotle picked intelligence as a precursor of the dexterous human hand. To us, however, it makes more sense to lean toward the human hand as coming before the mind. Though, in the end, I believe a combination of these two ideas would be the ideal one since, because we have acquired good hands that enabled us to use tools that in turn made us smarter and because we got smarter, we could use a variety of tools. There is a feedback mechanism between the two that made us both smart and dexterous.

Heidegger, too, thought that human hands have a lot to do with intelligence. For him, human hands are not just grasping organs as the other animals have. The essence of human hand, he believes, can never be determined. Its roots are found in thinking and manifested in handcraft.

> But the craft of the hand is richer than we commonly imagine. The hand does not only grasp and catch, or push and pull. The hand reaches and extends, receives and welcomes-and not just things: the hand extends itself, and receives its own welcome in the hands of others. The hand holds. The hand carries. The hand designs and signs, presumably because man is a sign….Every motion of the hand in every one of its works carries itself through the element of thinking, every bearing of the hand bears itself in that element. All the work of the hand is rooted in thinking. Therefore, thinking itself is man's simplest, and for that reason hardest, handiwork, if it would be accomplished at its proper time. (Heidegger, 16)

Derrida stresses the fact that Heidegger uses the definitive singular while talking about the hand. He states that humans have used "the hand" and not "hands" as it would be properly understood. For Derrida, Heidegger is talking about the essence of the hand as a large part of human thinking. This view is, to me, a correct one. Human hand constitutes an essential part of the humanity and its intelligence. It is not like intelligence is a different matter than the dexterity of the human hand. The evolution has drawn a parallel between the two. The more versatile our hands are, the more intelligent we are.

There is an indispensable relationship between the human hand and human mind. I believe what binds them together is handicraft in Heidegger's language or tool-use. Of course, humans did not just come to possess hands that are crafty. It was a matter of long evolutionary progress that started with bipedalism. Bipedalism is equal to having free hands that are not only available but also adapted for various tool-use behaviors. This adaptation of the hands is physical as well as neurological. The neurological changes in the brain must have had effects on the character of human intelligence and the cognitive capacities.

The aim of the present work is to seek the roots of human cognition. Somewhere in the evolutionary history, our cognition started to take a different path that is characterized by building extensively. We domesticated animals and crops, built cities, made tremendous number of tools. We are now even capable of destroying the whole earth if we want to. We use language to communicate complicated thought. We engage in scientific investigation both out of curiosity and to make our lives easier. We practice art and get aesthetic pleasure from artworks. We have little evidence, if any, whether animals also step out of nature in such a manner. We have doubts whether they really have consciousness. We are also more or less sure that they act more or less deterministically and probably do not have ethical concerns. It is hard to imagine their practicing philosophy, asking questions concerning the meaning of life or their purpose on Earth or even coming up with the idea of god. This list can go on and on.

Where did all this come from? It is a tough question to answer. We have no means of actually observing the changes occurring in the human cognition, therefore cannot locate what is really causing which development. Our situation is similar to that of detectives that arrive in the crime scene after the incident takes place. We see the result and not how it was before or how it turned out such and such a way. We investigate the crime scene to look for hard evidence that could lead us to the culprit. Likewise, we look at what is left from the human civilization to construct a story of what has really happened. If we are sure that it was an inside job, then we must a have a possible list of suspects.

In our investigation for finding the roots of human cognition, we do not have a long list of possible culprits. It is not the adaptation of liver that caused all this trouble, neither does it seem possible that changes in the construction of the eye was responsible for all that is to come. This question can be answered by locating what is different in the humans. When we look at the crime scene of ours, we see a pair of hands that is crafty and millions of tools. Honestly, it is hard to point to another possible culprit. Surely, we could talk about random mutations but that story would be highly unlikely. A philosopher engaged in such a retrospectively characterized investigation should do the same: find a suspect that is around the crime scene bring it under magnifying glass and see if there is any evidence linking it to the crime.

Our suspect is human hand and its tool-use. These are not completely separate topics. The human hand is almost equal to its tool-use. Hands are not things whose meaning lies in some essential limited purpose. Heart, for instance, pumps blood and that is the end of the story. But we have no way of listing out everything the hand is capable of. The more tools we have, the more the list gets stretched and we would always be missing out on the possible future tasks. The heart, on the other hand, will always have what it has currently. But the hand can come up with new tasks anytime, therefore it is a dynamic organ compared to the rest of the body.

Before anything else, it should be noted that the present work has an adaptionist tone regarding the evolutionary perspective. Though there are various versions of it, the adaptationist view gives natural selection more or less the leading role in the evolution of characters. They believe that the main focus of evolutionary biology should be adaptations. This view, however, did not remain unchallenged. Pluralists believe that natural selection is only one of the explanations. (Orzack&Forber) A historically important criticism was brought by Gould and Lewontin in 1979. They talked about the risks of a “failure to distinguish current utility from reasons for origin”. In more clear terms, the adaptionist view was biased to take the current function of an organ as the cause for adaptation. Adaptionists were seen by some as telling just-so stories to explain the presence of any adaptation. Although, I agree that there are risks in favoring natural selection as the driving force of evolution, I still believe that it is the strongest factor determining the biological make-up of an organism.

Having stated that human hand and tool-use could be, with strong possibility, the forerunner of human mind, we need to ask ourselves in what ways these can actually be related. What must really be shown is twofold: first we need to see what is special about the human hand and tool-use; second, we need to understand how these specialties of human hand and tool-use can have transforming effects on human cognition.

I will first focus on answering the first question: how different is the human hand and its tool-use. The human hand is not just like a grasping organ of any other animal. It is adapted for tool-use both physically and neurologically. Moreover, we see the role of hand anywhere in human dealings. We would not have anything if it was not for the hand. Human tool-use, too, is remarkably different than that of rest of the animals. Those differences, in turn, point to several cognitive differences that human mind might bear. It is my aim to draw parallels between tool-use and humans' related cognitive abilities and to do so by showing the evolutionary connections and the fact that they share similar bases.

In the third chapter, I will try to asses those elements that tool-use might have transformed in the human mind. This will be done first by picking out a few cognitive specialties of human mind and show how they are related to human tool-use and manufacture. I will point to a possible evolutionary connection between these by saying how these elements of human mind could have evolved through tool-use.

These characteristics will be explained in detail with regard to what they actually are and I will later try to establish their connections to human tool-use and manufacture. Spatial cognition and causal thinking are two important features that will be mentioned. If tool-use and manufacture had really transforming effects and since these are very basic to the workings of our cognition and language, then it becomes possible to claim that tool-use was indeed revolutionary in the progress of humankind.

As it is given in a title of a book (*The Hand: an Organ of the Mind*), the human hand is an organ of the mind; it is a reaching to the outer world. It receives data from it as well as drastically changing and manipulating it. The human hand, I believe, is what makes us aliens in this world compared to the rest of the animal kingdom. It becomes fit for tool-use, so do our minds. The one indirect aim in the present thesis is to show how special our hands are. Since we mostly take it for granted, we are rarely conscious of the life that is presented to us by the means of our dexterous hands. It becomes all more interesting if we could trace the brilliance of the humankind back to their hands and its tool-use. It is an exciting starting point and it could prove revealing in many respects.

CHAPTER 2

HUMAN HAND AND TOOL-USE

2.1 Human Hand

It most of the time remains reserved from us how much we are dependent on our hands. People who lost their ability to use one or both hands will be much more aware of this fact. It also remains hidden from us how versatile our hands are compared to other animals. In fact, we owe all the advancement we have made to our hands. Even if we were smart as we are now, we would not be able to acquire such a vast collection of technological devices. Think about it: we build everything with our hands, but a clumsy chimpanzee hand would never be able to achieve such progress even if it has the wits for it.

A high percentage of our daily engagements are realized by our hands. I wake up in the morning by the sound of my alarm clock and reach out to my phone to turn it off. I use my hands to rub my face in order to ease the process of waking up. I use my hand to open the door. I make coffee and prepare breakfast then sit down on my computer to exhibit my skills in typing and using a mouse by involving my hands in a specific manner which is only one of the numerous forms of using our hands without a single hardship. In fact, we have a huge repertoire of hand movements that are used accordingly. The diary of the hand continues forever.

There are many ways that make human hand so special compared to other animals. First of all, we have “free hands” which means we are bipedal, we do not need to use our hands for walking and we can carry our tools while walking. Frederich Engels use the wording of “free hands”:

> ...the decisive step was taken: the hand became free and could henceforth attain ever greater and skill, and the greater

> flexibility thus acquired was inherited and increased from generation to generation….has the human hand attained the high degree of perfection that has enabled it to conjure into being the pictures of Raphael, the statues of Thorwaldsen, the music of Paganini. (Radman, 204)

Obviously, he is referring to bipedalism that is now exclusively a human trait that once belonged to *homo* genus. Even apes, though they seem to walk in upright position from time to time, are in fact quadrupeds. They walk in a manner what we call "knuckle-walking" in which they use their knuckles to support the legs. They cannot maintain upright position while running for more than few seconds. According to Marzke ("Evolution of the Hand and Bipedalism"), we, in fact, became bipedals to free our hands. One could easily defend the reverse position that we possessed free hands because we became bipedals. However, bipedalism is hardly an advantageous trait. Although we are very good runners in terms of endurance, even the best athlete is slower than a chimpanzee. Bipedalism also brings about problems such as issues with back and neck or difficulty in giving birth. (Corballis, 186) For this reason, it is safer to assume that the former view is correct and "freeing hand" was the driving force to acquire bipedalism. Nevertheless, it is not vital for our purposes to prove it happened this way or otherwise. But this freeing of hands was not due to tool-use according to the archeological evidence. Tool-use appeared a lot later than bipedalism in the evolutionary line. However, it is still true that without bipedalism, we would not be able to acquire hands that are this versatile since they would not be used to such extensive degrees. In any case, bipedalism means free hands. It is technically not possible for a dog to hold a spear and chase after a cat to hunt it down. Bipedalism enables humans both to walk and use a tool. In this sense, it can easily be expected that an advantage in hunting occurs in our case. Hands, especially free hands, are better for using any kinds of tool than a paw or a beak. That is why genus homo already had the "upper hand" for tool-use. Once we had the hands that are suitable for tool-use, it was only a matter of time to complete the mental part of the story. So, I believe that the material condition of bipedalism that allows for effective tool-use also caused the intellectual capacity for it, as well as cultivating it.

Human hand is also famous for having opposable thumbs that enables us to realize a large repertoire of grasps but it bears many other faculties that make us versatile. Our hands are connected to our brains through a very complex neurological web. (Flanagan & Johansson) It even has a privileged position compared to other parts of the body. One may also want to refer to a very famous photo depicting an imaginary human being analogous to how brain might “see” the body.

Figure 1: In this photo, hands and lips along with the tongue are the largest emphasizing the fact that hands have a privileged status for the brain. (Agenskalna Klinika)

The human hand is also said to have 31 different types of grasps. (Human Grasp Database, “31 Grasps”) This surely provides humans with great advantage in tool-use. This large repertoire is not only about the forms that the human hand takes, but it is also about the force that is imposed on the object. While we need a strong grasp in opening a jar, we need to apply a very balanced force in handling, say, a needle while picking it up to avoid injury. Therefore, our success in tool-use does not only depend on the shapes that our hands may take but also on the application of the right amount of force.

Marzke has spent time on understanding where in evolutionary history we acquired our hands, by also doing research on chimpanzees. First, it seems chimps also have some sort of opposability but they cannot touch their fourth and fifth finger with their thumb, neither can they realize ulnar opposition, that is to touch the little finger side of the hand with their thumb. Lucy, a member of the famous *australopithecines* that lived in Africa about 3.2 *mya* and known as the first bipedal, also cannot perform ulnar opposition. (Wilson, 24) Although it is a positive trait for the apes and humans to have thumbs which are shorter than the other fingers - because otherwise it would be like having five fingers that look and act like four fingers without the thumb, which we know as utterly useless- it becomes too short in chimpanzees to use tools and look a lot like humans' hands in gorillas although they are never observed to use tools spontaneously. (*Ibid.*, 22)

Keeping the fact in mind that Lucy cannot perform ulnar opposition, Oldowan hand axes (the earliest and the longest period of tool-making), on the other hand, dates back to 2.6 *mya*; so it is safe to assume that human hand evolved through tool-use both physiologically and neurologically. In fact, Darwin was the first to mention the idea that human hand evolved through tool-use. (Darwin, 138)

Our thumbs are also what famously make our hands special and fit for tool-use. Even if opposability is not a distinguishing factor, human thumb is strong and powerfully muscled, through which, we can apply a significant force to the objects that we grasp. Aiello names three extra muscles that we have whereas other African apes lack which render us, in the end, have a unique capacity on tool-use.

> Because our thumbs are much stronger than those of other primates, the thumb bones, as well as some wrist bones, must also be stronger to resist the increased force….The evolution of powerfully muscled thumbs may have benefited early human tool users, as it does this latter-day axe maker from the village of Langda in New Guinea. The thumb must have been as heavily muscled. By inference, it would have come from a hand capable of generating the force essential for human tool use and manufacture. Our early human ancestors certainly did not have modern hammer handles to grasp or jar lids to open, but the same strong thumb would have been important for the effective manufacture. (Aiello, 1540)

Therefore, it becomes a strong possibility that our hands did not evolve by some random chance but evolved through and became adapted to tool-use. But the story should not end there. It is not only the physiology of the hand that evolved through tool-use by adapting to the requirements that such activity brings about; but also it is the brain that evolved according to such conditions.

The main function of the brain is to control the movements of the body not generating emotions; neither is it coming up with theories of physics or philosophy. The mental activity is secondary and basically a by-product of evolutionary adaptive processes and it cannot be found anywhere else in the animal kingdom. Therefore, before anything else, we need to be reminded that brain is an organ of the body that controls bodily movements and it is the primary function of it. And if we are talking about an evolutionary process that includes the physical changes in the hand and our hands become more versatile compared to the earlier form, then our brains must have also adapted accordingly.

One example to such adaptation is our extremely proficient hand-eye coordination. It is impossible to find an animal that can thread a needle as fast as we can even if we could find an animal that could do that at all. Hand-eye coordination requires a large investment from the brain and it is essential to our tool-use. With extensive tool-use, not only did the hand evolve physiologically, but also, because a refined series of movements might be required in a given task, the brain evolved and became more wired to the hand by also developing mechanisms that help realize such nuanced tasks. Therefore, we do not only pay attention to the hand physiology but also to "the hand in the brain". If we stop taking for granted the tasks such as typing on a keyboard, playing the violin or even hand-writing, we can see how much processing of information is required on the brain's part and it should have evolved extensively during such adaptations. If we remind ourselves the fact that the increase in the size of the brain was substantial during the advancement of tool-use and manufacture, we can see more clearly how this material change is mirrored in the brain.

There is much to say about human hand and its versatility; but suffice it to say, for now, not only that human hand is very proficient but it most probably owes its current shape to tool-use.

2.2 Tool-Use

If we are to suggest that human mind has evolved into its current form through tool-use, then we have to account for why it did not happen in the same way for animals as well. For all we know, we encounter countless examples of tool-use from animal kingdom. Especially, chimpanzees, our closest relatives seem to be able to learn how to use tools that we use. But, there are several criteria that will prove that human tool-use is qualitatively different from animal tool-use.

Over the past century, there have been many attempts to define tool-use by animals that do not necessarily exclude humans. Hall (1963) defined it as “applying a primary object to a secondary object”. (Bentley-Condit and Smith, 187) He did not see tool-use as an indication of intelligence. Another definition by Lawick-Goodall (1970) is "use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal” which also did not state that it is an indication of intelligence. (*Ibid*.)

It is important for us to see that tool-use does not need to bring about the discussion of intelligence. First of all, it is problematic to construct tool-use as a result of intelligent behavior because it is rather difficult to come to terms that define intelligence. Human beings as dominantly tool-using animals, we may like to view tool-using behavior as included in the spectrum of intelligence. But it is problematic to use human beings’ life forms as standards for intelligence.

Last definition comes from Beck (1980):

> the external employment of an unattached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself when the user holds or carries the tool during or just prior to use and is responsible for the proper and effective orientation of the tool (*Ibid*.)

The last definition talks about projection of a purpose. This could point to a discussion of intelligence however, we do not want a kind of comparison that involves our tool-use and that of, say, insects. This is not desired because there is a traditionally assumed gap between the human kind and invertebrates. One other issue is that in the observation of animal tool-use, there is always the risk of observer's interference while describing the act. But it might be the case that the animal might realize the act automatically and not even go through a phase of planning, establishing causal relationship and "eureka moment". Insects' tool-use is most probably a matter of automation rather than a planned and calculated attempt to manipulate objects and transform the environment surrounding.

When it comes to defining human tool-use, we have a history to look at. In the 1960's Mary and Louis Leakey found 1.8 *myo* stone-tool. It was later said to belong to Oldowan industry and associated with *Homo habilis*. It was an important discovery since *Homo habilis* had a larger brain size compared to earlier species and possessed other modern features that helped researchers create a scenario that they can link to modern humans. It even resulted in the inclusion of material culture in the official naming of a species, that is "Man the tool-maker". (Davidson and Nowell, 2)

Later, it was discovered that the situation is more complex than it seems. The oldest known stone-tool is approximately 2.6 million-year-old whereas the hominin lineage goes back as early as 7 *mya*. Researchers consider whether this "sudden appearance" of stone-tools were due to a dramatic change in cognitive capacity. (*Ibid.*) It is, however, hard to locate such a random change even if it really happened. I lean toward more to the explanation of transforming effects of material conditions on the appearance of stone tools and cognitive adaptation followed afterwards.

Two main classes of tool-making industries are Oldowan and Acheulean. Oldowan industry is said to occur when the first stone tool appeared, 2.6 *mya*. It consists of choppers, bone breakers and flakes that were made through "sharp stone flakes struck from cobble "cores" by direct percussion with another stone." (Arbib, 4.1) The key part was coming up with the idea of "flaking stones to create a chopping or cutting edge" (*Ibid*.). This is revolutionary since it reflects the very idea that human beings start to 'shape' the physical matter in accordance with the purpose of the tool. A random stone would not do the job and this fact is observed by the Oldowan tool-makers. A calculation is made as to which shape would help most to achieve the aimed goal and it was executed.

The Acheulean industry, on the other hand, appeared around 1.5 *mya* and lasted until 0.25 *mya*. It consisted of axes, picks and cleavers and was associated with *Homo erectus*. The key innovations were giving shape to an entire stone a stereotyped form by also chipping the stones to produce a bifacial cutting edge. According to Arbib, this type of tool-making required "manual dexterity, strength, and skill" (*Ibid.*). Therefore, throughout the Oldowan tool-making, *homo habilis* have gone through evolutionary changes that made them more fit to tool-making. The industry itself resulted in biological changes.

2.2.1 Differences between Human Tool-Use and Animal Tool-Use

Having defined tool-use in animals and humans, we can now talk about the tangible data. There are numerous examples of tool-use from animal kingdom. Chimpanzees do nut-cracking with the help of a stone or they use branches for termite-fishing in tree hollows. Another famous example comes from the infamously smart birds: crows. Crows are observed to drop walnuts on the street where traffic lights are present. They drop them when the red light is on, wait for the green light so that cars run over and thereby crack them, and go to the scene to pick up the reward. This is, at face value, enough to assume that animals do use tools. However, there are those who argue that animal tool-use and human tool-use are qualitatively different.

Vaesen came up with nine components of human tool-use that are deemed essential for tool-use and only one of them is present in chimpanzee-primate tool-use. These nine cognitive capacities are "enhanced hand-eye coordination, body schema plasticity, causal reasoning, function representation, executive control, social learning, teaching, social intelligence, and language" (Vaesen, 203). This is not the best account given. I think it is wrong to differentiate social learning from social intelligence and these from teaching. It is better to explain them in a monolithic fashion. Still, it does give some idea on the biological conditioning of tool-use. Without enhanced hand-eye coordination, for instance, it is impossible for humans to achieve such dexterity in tool-use.

Other good arguments come from Tallis in favor of the argument that human tool-use is different than animal tool-use. He states that although it is true that chimps have a kind of use of tools in termite-fishing, they do not, for example, re-use the tool. The branches they use are not 'made' but 'found'. Chimps do not engage in tool manufacture, namely secondary tool-use, that is, they do not "use tools to make tools". In nut-cracking, for instance, there is an immediate reward, whereas there is no such thing in the production of a hand-axe. Therefore, secondary tool-making requires a different planning ahead as opposed to direct tool-use and it points to a different sense of future. (Tallis, 225-6) In Tallis' own words:

> Secondary toolmaking, what is more, underlines the status of tools as tools; and, as a precondition and consequence of this, the implicit principles - the abstract sense of need, the general properties of the material the tool is envisaged to work on - start to crystallise out of the experience of being in a general environment. The traffic, what is more, is not just one-way: the tool is made because of an inchoate sense of the principle (of possibility, etc.) and the finished tool then makes that principle (of possibility) more clearly evident… (*Ibid.*, 226-7)

Napier says that it "involves a shift in cerebral activity from percept to concept". (*Ibid.*) This wording of concept is of importance here since it points to what becomes built in the mind through the tool-making process. Imagination undertakes a role that constructs a conceptual scheme that involves a relationship from a condition to a consequence: a principle. Thereby, the tool becomes the intermediary of such a principle and embodies a concept with its own existence. This surely constitutes a giant leap in the evolution of cognition.

Another significant difference of human tool-use from ape tool-use is that we make use of *polyliths* that are composed of *monoliths* by the help of *interliths* as formulated by Reynolds. Reynolds defines *liths* in the following way: "a distinct object, not fastened to a surface or another object, that can be rotated as a unit through all dimensions of space without falling apart" (Reynolds, 419). Therefore, a glass of water or a stack of coins are not *liths*. These *liths*, in turn, can be fastened together to form a new *lith* that can also be rotated as a unit. Chimpanzees, on the other hand, brings *liths* together by means of gravity and not by joints or fasteners. They can form, for instance, a stack of coins while we can make axes with handles. Reynolds thought this had immediate linguistic implications: "...human language presupposes what I am calling *polyliths*: an entity constructed out of parts which then functions as a unit through a range of subsequent transformations" (*Ibid.*, 423; *Italics mine*). In both cases, there is a flexible use of parts and wholes. To give Reynold's own example, the noun phrase "Cadillac owner" is used for different purposes in the following sentences:

> The owner of the Cadillac was cited for speeding.
> The owner of the Cadillac drove it back to the shop.
> The owner-of-the-Cadillac theme is a cornerstone of the advertising campaign. *(Ibid.*, 425)

In this way, Reynolds points to the fact that *homo sapiens* have a distinct capacity for dealing with parts and wholes and is very flexible in dealing with the situation. This is not only true for tool-use and manufacture but also true for language too. What becomes true for language might as well be true for cognition. This is a way to understand language and cognition as spatially grounded; it is based on conceiving separated an independent units and the ability to effectively bring them together. This similarity between language and tool-use is a substantial one. It could be an option that this was only a superficial similarity between tool-use and language; but then we would be missing a very important explanatory principle that could present a more or less unified picture of cognition. A lot depends on our ability to flexibly deal with parts and wholes and it is a vital part of our intelligence.

Levinson, in fact, questioned such a possibility that whether there is a necessary connection between cognition and language with regard to spatial thinking. Levinson stated that spatial thinking probably was "the evolutionary earliest domain of systematic cross-modal cognition" (Levinson, xvii) that is the domain into which the sensory data is translated as *spatial representations*. This could mean spatiality is the base to represent everything. Therefore, there is room for arguing that spatial cognition is the base for other concepts to build upon and human spatiality is dependent on the flexible use of parts and wholes. We observe this not only in human tool-making but also in language. In this sense, human tool-making gives a hint about the bases of human cognition. Thought this way, this peculiar way of tool-making that humankind possess may have caused the evolution of human mind to take a special direction that resulted in a mind that is preconditioned to think of environment as consisting of singular units that can be brought together in different forms. And this form of viewing the environment could have evolved through tool-use.

2.2.2 Language, Sociality and Imitation

Another way of showing the importance of tool-use is to picture it in the co-evolutionary web that it is located. Gibson establishes a complex relationship between tool-use, language and intelligence after a conference on the topic was held. She first reports a discussion that there exists an interdependence of social structures, linguistic communication and tool-use. They are "products of complex mutual interaction and feedback." (Gibson, 256) This is certainly not surprising. One can easily guess that there is a highly strict relationship among the three as it is the case even now.

One of the important relating factors is imitation. As a related concept, techniques that are defined as consisting of "primarily sets of acquired sensorimotor skills and action sequences" (*Ibid.*) are transmitted through social interaction that is dependent on imitation. It is commonly referred as a process of "Monkey see, monkey do". Gibson believes that the evolution of imitation has played a remarkable role in the advancement of technology. In fact, we have a tremendous tendency for social imitation compared to the rest of the animal kingdom. It could be well said that our advancement in tool-use fostered the system for imitation while our propensity for imitation also profited tool-use in turn. Gibson says it would be least expectable that without high dependence on tool-use, there would be any need for development in imitation, teaching and sharing. (*Ibid.* 257)

Gibson also believes there is also an undeniable positive relation between tool-use and language. While linguistic means help technology to be transmitted to future generations; technology, in turn, helps shaping the language. As Gibson reports, there are many language related technological means such as writing, printing and word processing. It is also well-known that many roots of Indo-European verbs depend on tool-use such as slicing and hammering. (*Ibid.*) Therefore, language and technology are strictly related.

Another point mentioned by Gibson is that humans master a high level of and greater number of information processing capacity as well as greater number of hierarchical levels which closely relates to human cognitive capacities:

> Since human technical, linguistic and social behaviours all manifest similar capacities of information processing and hierarchical organization, it is possible that the neurological and cognitive substrates underlying tool use, language and social organization may in fact be the same. Humans also have well-developed abilities to integrate hierarchically diverse behavioural domains. This permits concepts developed in one domain, such as that of object manipulation, to be integrated into another, such as that of language. (*Ibid.*, 258)

Both tool using and linguistic constructions are hierarchical in nature. The tests of block building that are conducted with children and chimpanzees have shown that human infants are better in hierarchical construct than chimpanzees. Humans definitely make use of more elements and a bigger number of hierarchical levels while constructing sentences, paragraphs and narratives although we might talk about chimpanzees who can speak sign language like Kanzi. Humans' cognitive ability of coping with high number of levels in hierarchical construct enables us to create complex buildings and machines. It also allows humans to engage in long-term complex projects that involves large number of members. (*Ibid.*)

Humans have also shown a lot better competency than cebus monkeys in placing objects in groups according to numerical or functional criteria although they also realize such tasks to a certain degree. This fact of our ability to group more capably and significant ability to master hierarchical organization points to an important distinguishing status of our minds. Not only that these are important to us in technological endeavor and linguistic engagements but because they are central to such activities, we can deduce that there is something specific about our cognitive power that enables us to realize these tasks. Since these abilities go hand in hand with technological behavior, we can very well say that it is possible that they evolved in parallel with tool-use.

Gibson also reports the discussion that took place in the conference whether it is possible that gestural communication involving the use of hands actually preceded oral communication. She says a certain overlap is found between the areas in the brain that control the hand movements and those control the mouth movements. (*Ibid.*, 260) This is, of course, important to our purposes if we can find certain neurological correlates between the hand movements and mouth movements since it would show that tool-use might possibly have paved the way to language as we know it.

In fact, the discovery of mirror neurons have led the way to such thinking that relates hand gestures to human language. In macaque monkeys, it has been realized that these set of neurons in F5 area for visuo-motor control of grasping are active during not only while realizing certain type of grasp but also while observing more or less a similar grasp. Thus a mirror system that is present is made use of both when observing and carrying out a definite grasp. (Arbib: 2008, 4) This mirror system for grasping in macaques also relates to humans' language related area in the brain:

> The region of the human brain homologous to macaque F5 is thought to be Brodmann area 44, part of Broca's area,

> traditionally thought of as a speech area, but which has been shown by brain imaging studies to be active also when humans either execute or observe grasps. It is posited that the mirror system for grasping was also present in the common ancestor of humans and monkeys (perhaps 20 million years ago) and that of humans and chimpanzees (perhaps 5 million years ago). (*Ibid.*)

This is clearly a bonding argument for how human gestures - and therefore human tool-use- might be related to linguistic communication. If it is possible that the language area of the human brain is also sensitive to data that come from grasping behaviors then it is also possible that these abilities have evolved together since they make use of the same neurological substrate. It is also quite obvious that the evolution of mirror neurons for grasping preceded speech. This is because language appeared very late in human history -around 100.000 years ago. This fact is also important for showing us that both language and tool-use have evolved with regard to the presence of another individual that is realizing the task and thus observed and imitated by the other through mirror neuron system. Imitation realized by mirror neurons found in both language and tool-use points to a possible strong connection in between the two and this can be demonstrated by showing that mirror neurons are present in the language area of the human brain that is a homologue of an area of macaque brain responsible for gestures.

Arbib calls the needing of another individual in the activation of mirror neurons as parity condition and states that it meets the condition of *parity* in language as well. (*Ibid.*) Language consists of a boundless set of facial, manual and vocal gestures and the conveyance of these set of gestures becomes possible through mirror neurons which have possibly evolved from those mirror neurons that were taking part in the imitation of manual gestures. This hypothesis is called Mirror System Hypothesis and is quite explanatory in showing how both tool-use and language are taught and learnt. It is also an effective way of showing the relation between hand gestures and language.

Arbib took his idea of mirror neurons to a next level by pointing out the differences in imitation in apes and humans. He believes that there is a difference of kind and not of degree when apes and humans are involved in learning by imitation.

He differentiates the two in two ways by calling what apes do as *simple imitation* while calling what humans do as *complex imitation*:

> (i) We can perceive -more or less immediately and with more or less accuracy- that a novel action may be approximated by a composite of known actions associated with appropriate subgoal.
> (ii) We can learn deeper hierarchies. (Arbib: 2011, 2)

If we are substantially better at conceiving a set of actions and repeating them in the expected way although they are more sophisticated than what other apes can achieve, then we may talk of ways that our cognitive strength is different than that of apes. It is quite possible that this sort of cognitive superiority have evolved through tool-use. Arbib compares Oldowan tool-making (it dates back to 2.6 million years ago to *homo habilis*) to that of modern chimpanzees while *homo erectus* have already passed the threshold of Acheulean tool-making by 1.7 million years. (*Ibid.*, 3) So, according to Arbib, there is a fundamental break that occurs in passing from Oldowan tool-making to Acheulean tool-making that marks the modern human brain as significantly capable than that of ancestors and other apes. As we know, there is a dramatic increase in brain size of our hominid ancestors in the lineage that follows from *homo habilis* to *homo erectus* and one could easily argue that this increase is due to the transition from Oldowan tool-use to Acheulean tool-use.

In the light of all these evidence that come from The Mirror Neuron Hypothesis and the fact that humans have a more complex system of imitation, we can see that an important role might have been played by tool-use in the evolution of human brain. Our sophisticated engagement with tool-use might have helped us master complex series of operations that are essential to our thinking and language.

We should not forget that learning plays a very -if not the most- essential role in not only tool-use but also in acquiring language and competence in thinking. If language and thinking are mostly learnt through imitation and imitation is perfected through the evolution of tool-use, then we can talk about the significant effect of tool-use in human history in the way that it resulted in such a mental competency that we have. In sum, the fact that we are good imitators made us smart at the end of the day and it is my proposition that this proficiency in imitation is fed through the evolutionary turn taken up that is characterized by tool-use.

There is also another study that discusses the difference in imitation that humans undertake and the rest of the animal kingdom. Primates are of course considered to be closest and to show a remarkable success in imitation, the studies are also centered around comparing humans with primates. Researchers believe that while humans demonstrate true imitation, the other primates only engage in what the researchers called 'emulation'. As defined:

> In 'stimulus enhancement' an animal watches a conspecific successfully solving a problem (e.g. cracking a coconut). This attracts the new animal's attention to the object and it will then learn more quickly by trial and error. In 'emulation' an animal observes a conspecific reaching a certain goal and tries to act similarly, although not behaving precisely like the conspecific. 'True' imitation is defined as the acquisition of skills by observation, resulting in novel behavior. (Roth&Dicke, 255-6)

2.2.3 Intelligence

Imitation is a part of a larger scheme; and most important of all, it is an integral part of what we may call intelligence. What is also important for our purposes is the discussion whether our minds are substantially different than those of other animals and whether we are more intelligent than they are. This is rather a tough question to answer because it heavily depends on how one might define intelligence. To many, it should never be the case that we compare the mental abilities of one animal to another since an incommensurability occurs if we pay attention to the fact that all animal kind inhabit different environments and all have peculiar way of coping with the environment and that is why it becomes impossible to come up with standard measuring method that can be used for all animals. It seems actually impossible to come up with meaningful criteria for intelligence if evolution has awarded each species with different ways of coping with their environments. Besides, what could be gained from such a discussion? What is aimed from the discussion of intelligence is not to reach an easy conclusion of the assumed high cognitive power of the humankind. We wish to know the characteristics of humans dealing with the environment in comparison to the rest of the animal kingdom. This way, we can highlight the path taken through adaptive processes.

We have mentioned the increase in brain size in *homo* genus throughout the evolutionary line, does that mean that brain size is what matters in terms of intelligence? Surely, the increase might point to an increase also in the complexity of actions that might be governed by the brain. But when we compare our brains to other animals, we do not see that such is the case necessarily. In fact, there are many other criteria that we need to consider when doing comparative cognitive science. But first, we should be able to define intelligence more or less with clear terms.

While some define intelligence as an aggregate of abilities of problem-solving that concern issues like "feeding, spatial-orientation, social relationships and intraspecific communication" (*Ibid.*, 250), we might want to argue that these issues do not have to be in the particular animal's agenda, therefore it does not become fair to use such criteria in evaluating intelligence. For instance, some animals are more social than others and they might form communities such as packs or herds or eusocial communities due to their adaptation to their environment, therefore become more competent in terms of communication. In this case, one might argue that sociality should not be included if it is not a universal in the evolutionary adaptation. But if we define intelligence as what includes the most adaptive processes, that is what works best in the wild; then we may have a right to include sociality in our conditions. We can easily then claim that social animals are more intelligent than the others since they have a better chance in survival. But one might easily disagree with the fact that we can favor sociality over non-sociality in terms of adaptation. Also, one might oppose to the idea that traits advantageous to survival are to be counted integral to what we may call intelligence.

It still remains as a problem what kind of standards could be used to evaluate intelligence. One answer come from the comparative psychologists: we use general problem solving and associative-learning abilities and these can be evaluated in unnatural environments such as laboratories since mental and behavioral *flexibility* can be a good indicator for intelligence in both humans and animals. This might as well be studied in the wild by looking at the 'innovation rates'. (*Ibid.*)

It still seems like intelligence could be an anthropocentric concept. For instance, we tend to take ant-fishing of the chimpanzee as an intelligent behavior but we are less willing to view the navigation skills of bees in the same way. There are two ways to go: first, we can say that the discussion of intelligence is meaningless because we get different standards for intelligence whenever we look at a different species. Or anthropocentrism is in the very nature of this discussion. We have said above that innovation rates or behavioral flexibility could be good indicators of intelligence but these are also domains at which humans excel. But, there could still be a lot to learn from the discussion of intelligence even though it is human-centered. One of the ways of doing so is to investigate whether intelligence and brain are related as it is believed traditionally.

Although, it is open to discussion, we seem to have a general idea of which animals are more intelligent than others. Commonly, it is believed that vertebrates are more intelligent than invertebrates, mammals are smarter than birds and humans are the most intelligent of all. Of course, anthropocentrism in this viewing of the picture is obvious and it hints that we seem to more or less know what intelligence is.

Roth and Dicke presume such gradation of intelligence in animal kingdom although they also accept the ambivalence in the definition and name such conviction as "suppositions". Then they proceed to what might have been the cause for such remarkable leap especially from other apes to humans. They first look at the brain size if it is really a conclusive criterion for intelligence. It turns out that elephants have larger brains than humans and monkeys also have smaller brains than ungulates although they are seen to have more cognitive and behavioral flexibility. Another extensively discussed criterion is relative brain size which means with increasing body size, brains also get larger. Although humans, by this criterion, have the largest brains, shrews that show little capacity for cognitive and behavioral flexibility have brains with percentage of 10 to their total body mass. Therefore, it is also problematic to use relative brain size as indicator of intelligence. (*Ibid.*, 250-1)

The researchers have also looked at the thickness of cortex that is determined by the density of neurons. It is mostly negatively correlated with the brain size in mammalian brain. Cats, for instance, have smaller brains than dogs but a more dense cortical structure. This number of neurons has direct influence in the number of synapses that are expected. Regarding this, human brain has the highest number of cortical neurons therefore scores the highest IPC that is information processing capacity determined by the number of synapses. (*Ibid.*, 253)

Still, the quantitative properties of brain seem to be far from explaining the leap between the animal kingdom and the human kind. We need to try finding if there are any qualitatively significant differences that mark human brain as distinct from others. Surely, all animal brains have developed different mechanisms that take part in assigned tasks of coping with the environment. Thought this way, the size of the brain or the number of neurons become unimportant.

But what kind of mechanisms or qualitative differences can we talk about as especially relating to tool-use? One of the possible answers is imitation as we have discussed earlier. The human brain might have evolved in such a way to accommodate tool-use and learning effectively. Other answers given by Roth and Dicke are theory of mind and syntactical-grammatical language. (*Ibid.*, 255) It is not obvious how theory of mind can be discussed in terms of specialization in the human brain but it can surely be a good parameter for intelligence in the humans. Language, on the other hand, is both indicative of intelligence especially because it plays an undisputed role in survival and has a lot to the with what the structure of the brain. Language will be discussed extensively in the following chapters.

One of the significant qualitative differences of human brain is that it is lateral. Corballis has seen laterality of human brain and hemispheric preference as one of the evolutionary landmarks of human evolution and believes it has had a large influence on our progress. The most visible implication of the lateral human brain is handedness which is our preference of one hand to the other. With percentage of 90 to 10 humans are right handed and there are many theories what might cause one to be left-handed or right-handed. Although lateralization of the brain in general is not a uniquely human attribute, handedness is.

There is an obvious direct relationship between tool-use and hand preference. In skilled tool-use, two hands are used in an asymmetrical fashion while undertaking different roles. In nine out of ten cases, right hand takes up the leading role in realizing the task involving tool-use. This role is mostly constituted of executing more or less spatially and temporally finer movements that are required by the task. A good example to such pattern is stone-knapping procedure in which dominant hand strikes a core stone while the other hand supports the core. (Steele&Uomini, 217)

Handedness most probably evolved through tool-use since a major requirement comes from such activity. Besides, no other primate seems to show any kind of preference except for the cases some apes seem to learn right-hand preference in captivity. And if we are reminded of the fact that language areas are mostly centered in the left hemisphere of the brain where right side of the body is controlled, we might have found a support for the theory that language evolved from manual gestures. Remember the discussion of mirror neurons. We have said that the area of F5 in the macaque brain contain neurons that get activated during both action execution and observation and this area is an analogue of Broca's area in the human brain. This was a way of relating manual gestures to language since Broca's area is known to be the language area along with Wernicke's area. In the same manner, it might have been the case that laterality involving bodily movements caused laterality for language as well. Although, surely, there are individuals who are left-handed and still use left-side of the brain for language dominantly. Therefore, it seems like such a claim cannot be substantiated. However, it still can be the case there was an evolutionary turn took place and hand-preference resulted in the development in language specific areas. In this sense, language and hand preference therefore tool-use might be related.

In this part, we talked of a wide range of topics relating to human hand and tool-use and manufacture. First, we have said the fact that humans are the only true bipedals enables us to have free hands and their evolving through tool-use both physiologically and neurologically. Human hand is quite versatile compared to other primate hands let alone claws or peaks. But behind this versatility, there is a background regarding the brain that adapted to subtle needs of the hand. One example was the advanced eye-hand coordination that allow for the production of shaped-edged stone tools which would be otherwise impossible to manufacture.

We, then, moved to the discussion of why human tool-use is so special that it resulted in causing the cognitive capacity of humans. Primarily, we focused on the differences of human tool-use and manufacture from animal tool-use. This issue, by itself, points to the intellectual distinctness of humans by showing the requirements that arise out of such tool-making industry.

One important difference of human tool-use from animal tool-use is that it is remarkably a social phenomenon since it is delivered over to the future generations cumulatively by way of language and teaching. Not only that, human tools are made into artifacts and they do not blend in the nature; in this way, they are kept as inheritance as a part of the material culture. The social dimension of tool-use and manufacture is undeniable. However, we are more interested in the cognitive development that followed tool-making industry. This is why, we are more focused on the biological changes that occurred in the *homo* genus especially after the appearance of first stone tools.

We have especially mentioned tool-making as a distinct human capacity. Animals use what is found in nature as it is found, in its raw shape whereas humans shape it into a tool. While chimpanzees use a branch as it is for termite-fishing, we give a pointed edge to a branch to turn it into a spear. There is the element of imagination and design in tool manufacture that requires a different intellectual capacity is at stake. A model of a principle is embodied in the tool in the toolmaking process and it requires a planning beforehand therefore imagination comes up with the design first through a clear-cut picture of cause-effect relationship. In animals, on the other hand, tool-use may arise out of random learning or through painstakingly time-consuming social learning in an only result-oriented manner without much consideration given to the design. Secondary tool-making that is use of one tool to produce another is also peculiar to humans that highlights the element of design. It is indicative of the fact that humans engage in tool-use without the immediate reward whereas in animals, it is never the case.

Another important difference between human tool-use and animal tool-use is that we can make use of tools that are consisted of parts joined together. This ability of humans points to a very basic but very important intellectual capacity. We perceive the world as consisting of self-standing parts that can be brought together in various combinations. This fact has, as will be discussed later, implications regarding the spatial cognition of humankind.

Lastly, imitation is another way in which humans differ from the rest of the animal kingdom. Surely, chimpanzees also learn through imitation but theirs is neither adequate nor appropriate in learning deep hierarchies. Regarding imitation, we have also discussed how mirror neurons might be a way of relating tool-use to language. Lastly, we have said that handedness which is cultivated through tool-use might have caused the specific laterality of human brain. In this sense, tool-use had a transforming effect on the evolution of human brain especially in the way that language is a left-hemisphere dominant capacity.

In all these, and possibly many more, senses; human tool-use and manufacture in the evolutionary history are linked to the evolution of human brain and therefore to that of cognition. In order for us to talk about the evolution of cognition, we need to talk about the structure of cognition. In the following chapter, we will take spatial cognition as the key to answer the question of how to link tool-use and human mind.

CHAPTER 3

EVOLUTION OF COGNITION

If we are seeking for the roots of our cognitive powers in our proficient ability of tool-use and making then we should find common grounds that relate the two. This is rather a tough question to answer since we are yet to arrive at an anonymous idea that could explain the underlying cognitive structures in our minds. Since we find many different features of our cognition that realize numerous tasks, it is hard to bring them under basic operations. Yet, I am going to suggest two good candidates for such a procedure: idea of space and causal cognition.

It is intuitively obvious why I bring up spatial thinking as related to tool-use and tool manufacture. This is due to the fact that a design of a certain tool and the use of it depend on a spatial mapping in the mind. It is most of the time an automatic process for us to handle a tool that we are accustomed to use; but when we are using it for the first time then a number of calculations are made to adapt to the tool. When a new tool is designed, spatial cognition is used extensively. Also, when a tool is used; proximity, the shape of the tool, the angle that it has been positioned comparative to the material, the way we handle the tool are all relevant to tool-use; therefore spatial thinking is intrinsic to tool-use and tool manufacture.

Causality is intrinsic to tool-use and manufacture. Without the idea of a subject inflicting on an object, we would not be able to come up with the thought and design of a tool specified for a certain task. Causal beliefs lie in the core of the idea of a tool. However, it remains a problem whether animals also do have causal belief and why we name it in a list that was supposed to be spared for human-only characteristics.

3.1 Space

There are many senses that come to mind when we think about the concept of space. The most common of all is the space that physics take as a subject. This conception of space is what Newton and Einstein had in mind. For Newton, it was an infinitely-sized empty container of objects and it was something that exists and not merely relative to objects as Leibniz thought. In Einsteinian understanding, we come to picture space as a united structure with time while the formulation changed completely: gravity, for instance, became the most important parameter that shape the conception of space. We will not be focusing on this sense of space in the present study.

Another sense of space is that we perceive the world in subjective terms and basically it is naive to think that our perception of the world is the mirror image of how the world actually is. Our project requires us to come up with an innate idea of space that is exclusive to humans. Since Kant was the first to state such an idea, I start with him. The whole project of the *Critique of Pure Reason* is to first suggest that there is an unfillable gap between the world and the way we *see* the world. Our way of seeing and understanding of the world is not only dependent on the sensory data that come from the outside world but also on our innate capacities. Our perception and understanding is by no means a passive process that is determined by the world, but an active one in which our minds participate. This participation is carried out by *a priori* structures that are two in kind: forms of intuitions i.e. space and time and “pure”, concepts of understanding i.e. *categories*. Kant sees this as the only way of doing metaphysics. We can only speculate about these and never anything outside of what are not determined by these *a priori* structures.

Transcendental Aesthetic is the part of the *Critique* that is concerned with forms of intuition. Kant starts off with a common definition Space as “we represent to our-selves objects as outside us, and all as in space." (Kant, A23) He goes on asking what this representation really is and if it is, along with Time, an absolute entity. This issue has a background: while Newton believed that Space did actually existed; Leibniz protested and said it is merely a relation between objects and has no absolute reality. Kant's answer is somewhat a combination of the two: space is absolute, but in a subjective sense. He gives several arguments in favor of such an idea which are actually quite convincing.

The first argument, Kant is trying to develop is whether space can be constructed as an empirical concept, he responds in the negative. The argument sounds somewhat circular but it is actually a strong one. Kant says if space were to be an empirical concept, to acquire the idea of space from the empirical data, I would still require the ability to represent objects in space, alongside one another. In his own words:

> ...thus in order for me to represent them as out-side one another, thus not merely as different but as in different places, the representation of space must already be their ground. Thus the representation of space cannot be obtained from the relations of outer appearance through experience, but this outer experience is itself first possible only through this representation. (*Ibid*., A24)

So in order for me to have the idea of space, I would need the idea of space itself. This argument is of importance for our purposes since it presupposes another argument: that the idea of space is about representing objects *alongside* one another. Kant has some right in assuming that the nature of space is its representing objects alongside one another, but one can imagine a perception of outside world without any representation of individual objects being placed alongside one another. Bats, insects or Martians could represent space very differently. Therefore, in this formulation of space, there is also the givenness of objects represented as separate from one another.

His second point is that Space is an *a priori* form that grounds any kind of experience of objects. Kant justifies such a claim by saying that we can always imagine an empty space devoid of objects but we can never imagine an object that is not found in space. In this sense, space becomes something as "....the *condition* of the possi-bility of appearances, not as a determination dependent on them, and is an *a priori* representation that necessarily grounds outer appearances." (*Ibid.*, A24; *Emphasis mine*.) However, the fact that we cannot imagine an object without being represented in space is caused by our tendency to imagine objects as "delimited" and "separated" from other objects. When object is delimited, space surrounding it naturally arises. Therefore, I believe, it is not space that comes first but the object. Here we see how our understanding of space is related to our conception of objects. We are very much biased in understanding of objects as delimited and self-standing things in a very similar fashion to Reynold's conception of *liths*. These were, as it can be remembered, self-standing parts of tools that are brought together by means of joints. They invite the discussion of delimitation automatically as it is in the Kantian account.

There are other explications made by Kant concerning the nature of space in the *Critique*. For our purposes, however, two issues are of importance as they are emphasized above. One is that the idea of space in the Kantian account seems to include a presumption on the definition of objects. Objects, in this account, are with margins that draw their limits and they are represented in space as such. For instance, while a loaf of bread is instinctively an object, we cannot say the same thing for atmosphere. And as it is said in the beginning, what spatial cognition does is to represent object. In this sense, space and objects must be co-defined. It is not as if there is the definition of space that is given independently from that of the objects. This is important for us because we want to establish the idea of space on the grounds of objects as delimitation and empty space is only secondary to this base. Meaning, we are predisposed to perceive the environment around us as consisting of delimited objects. Secondly, the empty space that we can imagine in infinite magnitude is merely what is left from the drawing of limits to a particular object. Kant says we cannot imagine an object without representing it in space; but this might be very well due to the fact that representing object includes drawing its limits and that necessarily requires an outside space following naturally. Moreover, we also secure the definition of object in the Kantian account as delimitation since he believes that we can never represent an object without representing it in space. This would clearly mean that what he understood from objects is that they are given in margins.

Think of what we generally understand from an object. Infants tend to first learn words that are more or less very simple. Probably following the words like “mommy” or “daddy”, the infant might learn the word “ball”, for instance; and not the word “space” or number “19” or “door knob”. The concept of ball is more intuitive to a child of that age than anything more abstract. A ball is a perfect example of a concept of an object that is most intuitive to human beings. It is a perfect *lith*, to speak Reynolds’ language. When I think of a ball, I immediately imagine a ball whose limits are clearly defined in space. Kant is right, I cannot imagine a ball without representing it in space. But it is due to the fact that drawing any limit of an object implies an *outside* by definition. An idea of space follows immediately. Therefore, concepts of object and space should be *co-defined*.

Numbers and our ability to count is an indication of the abovementioned way of understanding of spatial cognition. Natural numbers, as the name itself states, are used to represent whole objects, things, beings. They come to us naturally; unlike integers, which imply negative being that are not ‘naturally’ intelligible to us. (We could talk about having negative money, in the sense that we are in debt but it still implies a sort of abstraction.) Natural numbers represent whole things that are found around us. If I say there is one thing, I mean that there is a single delimited object found in space and any other object found equals to this original object . If I say two objects are present, I mean that there are a and b objects in space and they are not equal to one another. One can easily think that through the understanding of one and two, one could easily understand the whole natural numbers because we make use of the same operation over and over. In fact, in Turkish, number two, namely *iki*, comes from the word *eki*, which basically means in today’s Turkish “its supplement” or “its addition”. As it is explained:

> ... the Verb… (ek-mek), ‘to sow (seed), to sprinkle (salt, etc.); in Tshagatai (ik-mek) ‘to sow, to insert.’ The sowing is a throwing or a casting of the seed, and therefore the Noun *ek-i*

> signifies anything thrown down or added to something else: an addition...(Koelle, 147)

It is natural to think that once one and two or *addition* is understood, one understands the logic behind natural numbers because we can *add* to the *one ad infinitum*. However, I believe the real virtue lies in the understanding of one and not two; because understanding of *one* is predicated upon the understanding of delimitation, act of separating. Understanding of delimited one is enough to use it recursively. But this operation is not exclusively about separation but could also mean merging of things. As the inscription on both of two planks forming a bridge in Pentland hills in Edinburgh beautifully said: " That which joins and that which divides is one and the same." (Hughes, 1) Separating and uniting are one and the same operation. If one understands the former, he understands the latter as well, and *vice versa*.

Therefore, we have an intellect that works with parts and wholes all the time and is very flexible in dealing with composite objects; be it a tool, or a sentence or even numbers. It should not come as a surprise that we are probably only creatures that can count or do any other kind of mathematics. Although this view is challenged by many experiments, it is not obvious if animals can genuinely count. Naturally, if animals cannot count this could be informative of the fact that they are not good at coping with parts and wholes. Tallis, for instance, ask the question to those who argue that rats can count up to three: why do they stop at three? Counting, by definition, can be applied *ad infinitum* and there is no reason whatsoever for any animal to count up to three and not more. (Tallis, 200) Therefore, animals' counting can be regarded only as a pseudo-counting and dependent on magnitude, and not on *real* sense of numbers that is an abstraction of a concept of a delimited object found in space. In fact, an issue on the topic *Space, Time and Number: a Kantian Research* is published in *Trends in Cognitive Sciences* in which they look for neurological bases that could imply any connection between these concepts. (Dehaene&Brannon, 2010)

One related issue is concerning our ability to point to objects. It seems animals do not understand pointing while human infants learn pointing even at prelingual period. As Lock pointed out, when a 12-month-old fails to acquire a certain object, it first makes noise to catch the parent's attention and later point to the object in question in order to make the adult fetch the object for her. (Lock, 281) Since this happens in presymbolic phase, this could mean that human infants actually learn how to conceptualize about objects before they learn their names. This capacity could point to our innate readiness for perceiving such an environment, an object-centered understanding of space and a tendency to single things out once they are separated from the rest. Surely, this is done by the use of our hands and is indicative of the role of the tool-using hand in spatial cognition.

If we pay attention to the evidence that come from pointing and counting, it becomes easier to see that we might indeed have a strong tendency to picture the world as consisting of delimited objects. Surely, in modern life we have numerous tools that we handle and since we have hands, we can grasp and separate things from the rest of the environment all the time. Therefore, it may come natural to us to think of the world as such. However, I am talking about a cognitive aspect that is also supported biologically. Our brains and cognition have evolved to perceive the world as made up of parts that can be brought together and fit to single out an object easily in a given environment as opposed to other animals.

How do all these relate to tool-use and manufacture? Spatial cognition is the base to tool-use and manufacture. If tools are taken as cultural atoms and if our brain and cognition evolved to match the necessities of such endeavor, then our spatial understanding might have been shaped accordingly. And spatial cognition might be one of the central cognitive niches that help us understand how our minds work. In the Kantian account, for instance, space as a form of intuition precedes the working of concepts of understanding. Space is more basic than the *categories* of the mind. That is why we have enough reason to believe that spatial cognition is foundational to the functioning of the mind.

Now, I have said the spatial cognition must be dependent on the understanding of objects as self-standing and delimited units. This is very similar to Reynolds' formulation of human tool manufacture. He claimed that while human tools are made of what he called *liths*, other animals never make use of them. These *liths* are self-standing parts that are joined together to form a further *lith* which is also self-standing that can be rotated in space without falling apart. While humans both practically (tool-making) and cognitively (numbers, geometry) seem to have mastered this craft, it is possible to draw parallels between the two. These parallels can be drawn through determining space as the base to these practices. The spatial cognition lies the foundations for tool-making, geometry, arithmetic and so on.

This specific form of tool-making means everything to us since ours depends on realizing such a task with success and flexibility. This also may account for how our spatial cognition may have worked. The similar base among our tool-use and spatial cognition, I believe, is not accidental. If we did not happen to acquire such a spatial cognition it would not be possible for us to come up with such a variety of tools almost all of which are of composite structures.

Such an understanding of the world around us -seeing the world as made up of parts- is remarkable. But it is hard to tell whether we gained this viewing of the environment through the tool-centered evolution or because we acquired this sort of cognition, we came to have such a vast inventory of tools which are consisted of parts. Probably, both are true and there is a feedback mechanism between the two. Once we started to make composite tools, say a stone axe with a handle, we began to evolve in the way that can carry the cognitive adaptation that what follows such innovation.

One might claim, though, this is not how humans perceive the environment. It is more like a wholesome perception of the world in which particular objects do not stand out by themselves. It would be overwhelming to receive such rich data. In fact, most of the time, we become *attuned* to our environment after repeatedly being exposed to it. I may see the hammer with its physical qualities when I first see it and be somewhat clumsy while using it. After a while, the hammer become almost transparent and I stop to perceive it as an object that 'lit up' and standing out in the environment. The first mode in which I am not familiar with the object in question called the *online* mode while the other one after learning and attunement called the *offline* mode. The spatial perception in two modes is different, in fact, contrary to one another. In the former mode, the object is represented with its physical properties therefore with clear limits to rest of the environment. This mode is similar to what Kant had in mind in which objects are given as being next to one another. But, according to embodiment theorists, we almost never perceive the world as such. Most of the time, the things appear to us as fused into a singularity. Therefore, we need to make this distinction to avoid confusing the two. It is important because we need to see that the *mapping* mechanism in the online mode is used when we are carefully looking at things around us. It is also quite possible that only humans make use of such mapping. This mapping system works very much in the same way as our engagement of parts and wholes. This mapping system of objects around us, as is seen in our example, can be also used for language. A good example to this comes from learners of a foreign language. In a foreign language in which we are not fluent, we carefully pick the words and put them in order by reminding ourselves the rules of the language one by one. In our mother tongue, however, we speak effortlessly mostly without being aware of the mapping in the sentences.

3.1.1 Language

Language is perhaps the most important result of this cognitive development. As Reynolds also pointed out, human language is founded upon the principle of bringing together self-standing parts into more complex structures. This is visible in the example of "The owner of the Cadillac". The word "owner" and "Cadillac" are units that are meaningful on their own. But they are joined together to form a more specific meaning that can be conveyed to other speakers of English language just as the axe with a wooden handle.

Language is also about bringing single units together in a rule-governed manner. In using a language, we can *merge* meaningful bodies to form a further meaningful body. The Merge theory under the Minimalist Program by Chomsky in linguistics is basically about such operation being used all the time; that we form larger bodies of phrases out of simpler ones. (Chomsky et al.)This is what language is basically about according to Chomsky. In Chomskyan understanding of linguistics, we are all born with internal language that is different from the surface language which is the language we use in daily life. This internal language, so to say, deep grammar is inherited biologically. In this sense, we can connect this Merge operation to our theory: human mind is extremely good at synthesis and this ability might have evolved through tool-manufacture based on making tools that are composite of parts. As simple as it may sound, it is a cognitive base that is vital to both our thinking and language. It is also quite possible that a leap forward in spatial cognition that is led by the intensification of tool-use and manufacture has resulted in such a remarkable development.

Another linguistic concept that has ties with tool-use is recursion. Corballis, for instance, believes that recursion is peculiar to humans and it might have single-handedly caused the cognitive revolution of the human mind. Recursion is not only linguistic but also seen in mathematics and geometry. It can be informally defined as embedded structures depended on the repeating of the original pattern. Corballis believed that even Theory of Mind would not occur if we did not possess recursive thinking.

Recursive thinking is visible in tool-making as well as language. We build "engines within engines, wheels within wheels, computers within computers". (Corballis: 2007) It is also shown that sewing and basketry are based on the elements of recursion. (Coblijn and Gomil, 2010) Also, the fact that we re-use our tools might have paved the way for recursive thinking. Lastly, it is possible that tool-use with deeper hierarchies challenged the human mind and pushed it towards the dawn of recursive thinking.

Human language is believed to occur in the last 100.000 years which is very recent in human evolution. We have enough reason to believe that what took off in the making of composite tools culminated in the appearance of language as a syntactical structure. Action sequencing (especially in tool-use) and syntax are believed to be in a co-evolutionary relationship according to the research done on the functions of Broca's area. (Stout&Chaminade)

We should also remember that creating composite structures may also bring about the ability to disintegrate them into smaller pieces. They are two sides of a coin. Think of our aspiration in chemistry always to find indivisible units of which the world is made of. First, we have found atoms; then smaller parts like electrons or protons. For a time, we thought that they were the building blocks that make up the universe. Finally, we have come to see that behind the particles, we have waves and our intuition concerning parts and wholes is only helpful to some degree in understanding how the universe works.

Another evidence that can help us relate tool-use with language comes from aimed throwing. Aimed throwing has been shown to be in support of the pre-adaptation of language. According to this account, aimed throwing requires a planning and sequencing of actions which might have prepared the grounds for language to emerge. In order to throw or use a tool effectively, certain sequencing neural machinery is said to be necessary to come up with a planning for action sequencing. Consequently that very machinery might have been adapted for other functions, say communication. (Calvin, 231) Calvin's hypothesis was later examined in the light of the mirror neurons theory, and it was discovered that there is indeed a correlation in the brain structure between aimed throwing and a homologue in the Broca's area, during research conducted on captive chimpanzees. (Steele&Ferrari&Fogassi, 6)

I have mentioned earlier the fact that when a tool that is shaped into a certain form, it stands out in the environment as carrying a symbolic weight on itself. It bears a meaningful context attached to itself as a name does. The tool, therefore, itself is a sign. It is a sign to a concept that is formed by the very presence of the tool and its meaningful context. Language, too, works as a sign conveying system that is comprehended by both parts that speak the language. The word for a weapon, say "gun" and a gun itself both can convey the message of threat. They are both signs to a life-threatening situation. Humans are, in this sense, sign using animals and tool manufacture might have contributed to the evolution of language. The production of a tool is also a production of a sign. However, it is rather a tough topic to track the roots of signs and their biological conditions, let alone their emergence.

Moreover, as it is mentioned above, there might be a strict evolutionary relationship between tool-use and language in the sense that our brains might have evolved to be very fit to realize tasks such as detailed action sequencing in the tool-use and this fitness, in return, might have culminated in our ability to process syntactic structures. Intuitively, one might see how they might be related. Both language and tool-use and manufacture require coming up with arrangement that is spatiotemporally planned and executed. In the sentence, "I moved the table next to the door" is a sentence that is constructed by stringing words together by applying syntactical rules to form a meaningful string. In tool-use, more or less similar scenario is the case.

The intensity of spatiality in the metaphors also shows us that we have a dominant spatially-oriented way of understanding the world around us and even very abstract terms such as emotions are expressed in such a way. It becomes easier for us to grasp the meaning behind the expression when put in spatial metaphors. It is also true for etymology of the words too. The word "grasp", for instance, is used for "understanding" or "comprehension" while it originally means "to get a hold of something". Many other languages, also use the same metaphorical sense. In Turkish "kavramak", in German "begreifen" and in Arabic "fehm" as in "mefhum" all mean both to get hold of something and to understand as the same time. It seems like the metaphorical usage may work in the same way even across languages and cultures. In this sense, as well, we can observe the comfort of ours with spatial terms and therefore deduce that our cognition have evolved with characteristics that are more fit to comprehend expressions that are rich in spatial imagery.

3.2 Causal Thinking

Causal thinking is basic to all human endeavor, tool-use and manufacture being in the first place. In fact, it is a tough question to answer from where it came. But, first we need to clarify whether it came out of nowhere or we see the traces of it in the animal kingdom already and in the primate evolution. I believe even if it is true that causal thinking is not special to humans, we still need to admit that evolutionary development that followed tool-use has resulted in a more advanced causal cognitive capacities.

We already know that animals, especially mammals and more specifically primates, use tools. A simple logic might tell us that they also involve in causal representations similar to ours. However, this may not be correct. There are cases of insect tool-use but our intuition tells us that their tool-use does not have such a mental capacity at the level of setting a goal, planning ahead to achieve that goal and executing the plan. Therefore, not all tool-use may point to causal cognition and we should always beware of anthropomorphizing the matter.

First of all, we need to make the distinction of habitual learning from genuine causal representation. A rat can learn to press a lever to acquire food, for instance. Surely, a chimpanzee can use a stick for termite-fishing. But, does that mean that they actually represent to themselves a relationship of cause and effect? Or do they basically become conditioned for the procedure? These are tough questions to answer since we have no way of monitoring if they really engage in contemplation on natural forces.

In order for us to see whether humans distinctly understand the relationship from cause to effect while other animals, especially tool-using ones, fail to do so; we need to compare their tool-use behavior in detail. The reason for us to do so is to explain the technological leap between humans and other animals and a cognitive difference might account for it. A good candidate for such a difference is the understanding of causality and humans might have evolved mechanisms that are fit for tool-use and manufacture in this sense. This mechanism, in the end, may have helped humans with not only in making tools but also in building shelter, doing science and many other aspects of human life that are directly or indirectly related to this cognitive ability.

We might, quite naturally, have to deal with yet another chicken-egg question. Did causal cognition come first or did it follow technology? It seems both theories have some truth about it. Without causal cognition, it seems, we cannot achieve complex technological advancements; and without technology pushing for adaptation, our brains would not have evolved to meet the needs. Probably, it is safe to assume that both were true. But I believe the latter theory has more truth. I have already said that technology might be possible without genuine understanding of cause-effect relationship. So, it is probable that tool-use had become a significant adaptation for the *homo* genus from the very beginning of bipedalism which had freed the hands for tool-use. After such a point, the cognitive development might have followed through as technological endeavour demanded.

We must be careful while talking about cognitive development as opposed to the adaptive processes that happen in the brain. This is due to the fact that our cognition does not only depend on our own individual intelligence but we share it as a group with ever growing cumulative knowledge about the world. Therefore, the exponential rise in technology may not have an equal counterpart in the brain. Surely, we are not the only social animals; but, we have artifacts that we pass on to future generations and this accounts for a cumulative material culture.

In fact, Dunbar believed that humans are the species that can maintain the largest number of personal relationships. He found a correlation between the neo-cortex size and the number of the group in which an animal kind lives. While humans are at the top of the list with the largest neo-cortex, loner cats like cheetah have significantly small neo-cortex. Therefore, sociality of humans plays a very important part in the technological development and we must be careful while looking for reasons of such a great leap forward. We should remember the social aspect to the problem of evolution of technological cognition and distinguish it from what happens in the brain.

Going back to our original question, do humans indeed have a qualitatively distinct ability for technology? It seems the answer is yes and even the closest relatives of humans and notorious tool-users, primates, fail to show an understanding of cause-to-effect relationship although they do show tool-use behavior. Apes, for instance, cannot point to the appropriate tool that is required unless they go through extensive training. (Wolpert, 1711) This shows us that they have very little understanding of natural forces. We also know that it takes five years for a chimpanzee to learn nut-cracking from their mother, while it is a very simple task for a human infant. This implies that tool-use by itself does not point to a sharp perception of forces in nature and there certainly is a difference between humans and the rest of the animal kingdom in terms of understanding causality.

Wolpert thinks tool-use by animals and realizing tasks that, at least at face value, require the understanding of the concept of force might be deceiving:

> It is not that chimpanzees lack visual imagination or are unable to learn quite complex tasks by trial and error, but they do not reason about things. They have, for example, no concept of force, and even worse, no concept of causality. They do appreciate that contact is necessary in using a tool to get food, but will focus only on the contact and not the force it generates on the target object. A hook at the end of the stick is not perceived as a means of getting the reward. One may illustrate the differences in chimpanzee and human thinking with the claim that an ape seeing the wind blowing and shaking a branch till the fruit falls would never learn from this to shake the branch to get the fruit. (*Ibid.*, 1712)

Wolpert reports that developmental psychology has provided us with the knowledge that infants as early as few months old perceive the world in some sort of a mapping consisting of solid objects that more or less keep their form whether they are stationary or moving. These objects seem to have a mechanical component to them in the eyes of infants and this component gradually evolves into something similar to the concept of force. This conceptualization is consistently present in the age of two to three. He believes that some sort of cognitive ability that is characteristic of humans, perhaps a module, surfaces and this conception of mechanics might have evolved in early humans as a key property in the brain. (*Ibid.*, 1713)

We have, therefore, enough reason to believe that causal cognition in humans might be something really special to us. Although it is possible to show tool-using behavior without such a causal cognition, it is not plausible, as Wolpert thinks, to build complex tools that require a different mental capacity. By complex tools, he understands: "...a tool that has a well-characterized form for the use to which it will be put and, even more importantly, any tool made out of two pieces put together, like a spear with a stone head" (*Ibid.*, 1714).

All in all, it seems that humans might have evolved a special cognitive mechanism that is characterized by the understanding of force and the relationship from cause to an effect. This mechanism has probably evolved from the intensification of tool industry and the cognitive requirements that it brings. In fact, it is known to us that the transition from Oldowan to Acheulean tool industry is coincided with the evolution of *homo erectus* from *homo habilis* with a significant increase in the brain size. Somewhere along the way, it is possible that changes in the tool-industry resulted in the reshaping of the human brain therefore of human cognition.

CHAPTER 4

CONCLUSION

The overall aim of the present work was to establish two main facts: how the human hand and its tool-use are special and in which ways it could be related to the evolution of human cognition. While the former has already received attention and, in fact, been studied, the latter has almost never been taken as a central theme. Therefore, a new angle has been brought to the area of the evolution of cognition. At times, it becomes hard to support the argument as well as coming up with a knotting point between the cognition and the hand.

The first chapter has first focused on the human hand. What primarily should be understood about the human hand is how it is a result from bipedalism. What is important about the hand is that it is free for any task that might come up. The hand is available for carrying and using any kind of hunting equipment, say a stone or a spear, while running after a hunt. It is also plausible that the evolution of the hand had its origin in bipedalism since once they are not used for walking they can become more adapted for tool-use. In fact, we have a theory at hand saying that humans became bipedals to free the hands, meaning, to use them for other purposes. At this point, this theory cannot be fully substantiated. Still, whether this is true or not, one fact cannot be denied: humans have the upper hand for tool-use in comparison to other animals because they are bipedals and hence have free hands.

Human hand is special also in other ways. The opposable thumb with the optimum measurements is one of them. Although it is true that apes also do have opposable thumbs, their thumbs are too short for the rest of the hand and this causes a lot of trouble in realizing many tasks. They cannot, for instance, realize ulnar opposition. The repertoire of the human hand is a lot wider than any other primate hand, if one can truly call them hands. What is more, human thumb is powerfully muscled. This is the base to many of our tool-using behavior. We would not be able to open a jar, for instance, without the merits of our strong thumbs. It is concluded that these strong muscles, since we have them additionally and they were not present in the earlier hominin physiology, have evolved through tool-use. This is barely a new idea even Darwin had thought of it. And we have somewhat good support in favor of this argument.

The changes were not only present in the physiology of the hand but also in the brain as well. Versatility of the hand largely depends on what brain does with the flexible physicality of it. Advanced hand-eye coordination was one example given. Without this, almost all tool-using behaviors of ours would be realized, if they truly can be, with painstaking effort and a visible clumsiness. Hand-eye coordination is surely always open to development through practice but humans have a strong propensity for it. It is quite plausible to think of this ability as having evolved extensive tool-use over generations. This points to the fact that it is a lot more realistic to keep in mind the transformation of the brain as well while talking about the developments in tool-use.

After the discussion of the hand, I discussed tool-use with detail. Tool-use is a historically problematic to define. But one definition seems to be more influential than others: the employment of an unattached external object, but there are problems with this definition as well. For humans, there is the background. Oldowan and Acheulean are two main industries. Animals seem to use tools although not with that much of variety and skill. But there are differences between the animal tool-use and human tool-use. Some work has point out to some basic element such as sociality or causal reasoning as present in human tool-use but non-present in animals. Also, humans involve in manufacture of a tool while animals use what they find in their environment. Tallis talks about secondary tool-use which means to use one tool to manufacture another as a distinguishing factor between humans and animals. Reynolds, on the other hand, points out that animals do not make use of tools that are composite of more than one part; humans can make tools made out of joints. This is important for our purposes since it shows how good humans are in dealing with parts and wholes. Imitation, too, along with the given social context strengthened by the use of language, is a strong factor that proves human tool-use different from animal tool-use. It is also stressed that humans are more competent in understanding structures with deep hierarchies and without doubt language is of such a structure. It could point out to parallels between language and human tool-use. Possibly this list is longer than what is given here. And why is this investigation done? It is because I have endorsed the view that human cognition might have evolved through tool-use and if animals also do use tools, then we must come up with an answer that can explain such difference.

In relation to the discussion of imitation, the discovery of mirror neurons has changed the panorama. These neurons have proved to be located in areas of the brain that are language related. In such a way, it became possible to theorize on the relation between hand gestures and language. Surely, these language specific areas have occurred in the brain very late in the evolutionary line since language is a very recent phenomenon. In sum, the role played by tool-use becomes evident if we pay attention to how closely imitation and mirror neurons are related and any development of these two can be traced back to tool-use. In short, tool-use has probably fostered the activities of mirror neurons by making them available for imitation.

One umbrella term that could bring under the abovementioned elements in the mind is intelligence. Remember that our starting point was to locate the origin of the human cognition, therefore intelligence. But intelligence is hard to define since there are conflicting ideas concerning what constitutes it. Brain is the first answer that comes to mind and we have said that it is not exactly off the track. The laterality of the human brain is also discussed in relation to handedness. In fact, Corballis believes that what might be distinguishing humans from other animals could be its lateral brain and such brain might have evolved through tool-use since in proficient tool-use a preferred hand is required.

In the third chapter, I posed elements in the human mind and stated that they might have evolved through tool-use. These elements are spatial cognition and causal thinking. I have discussed the characteristics of human spatiality extensively. Starting with Kant, I have tried to prove that human spatial cognition has a bias for delimitation of objects. There are many ways to demonstrate such viewing of spatial cognition. Aimed throwing and pointing, for instance, are human only acts; animals neither throw things to each other or at other things by aiming nor do they understand pointing. This could show us that we are in fact inclined to perceive the environment by singling out objects. We may see the world as composed of parts, delimited objects. This has a lot to do with our way of tool-making. We make tools that are made out of more than one part that are somehow attached to each other. Moreover, we actively use our free hands to handle an object which is the act of separating it from the rest of the environment. Hands both attach and separate. Taken this way, almost all human endeavors depend on this smooth co-working of hands and cognition. I have also discussed language in relation to tool-use and manufacture. Many researches have shown possible connection between the emergence of language and tool-use, this connection can easily be constructed by means of spatiality.

The last point in the chapter is concerning causal thinking. It is my argument that the developed and alert causal cognition that we have evolved and gotten sharper through tool-use and making. There is an obvious correlation between the two and evidently human beings are good at both causality and tool-use. To start, we have discussed that if animals, too, have causal thinking if they use tools. We eventually concluded that there is a risk of anthropomorphism there since animal tool-use may depend on principles of habits, instead of planning ahead for instance. We later discussed the feedback mechanism between technology and causal thinking because they are systems that support each other.

Since I was talking about the evolutionary relationship between causal cognition and technology, I have pointed out another relevant issue: the evolution of cognition is not only dependent on the individual cognition but also on the social cumulative intelligence. In this case, the cumulative intelligence may not match any kind of trend of biological change. Afterwards, I have come back to the important question of whether animals also have causal thinking in case they use tools. This question is crucial to ask because I am pondering on the possibility that characteristically different human tool-use has led to causal thinking. In any case, Wolpert thinks animals do not understand the concept of force. Their tool-use is based on systems like trial and error. This shows us that animals most probably do not have causal thinking. Wolpert also mentions how infant of early age start to develop a pseudo-conception of force and this conception goes on to evolve through the developmental stages. Once concretely substantiated, these facts could prove it is only the human mind capable of genuinely understanding causality. After such point, we can discuss the necessary relationship between the two and it is most probably the case that technological turn that humanity took has resulted in causal thinking.

All in all, I have discussed how much difference a prehension organ like the hand could make. It will probably be impossible to completely unravel the mysteries of the human mind. But the hand is a starting point and the technology is a transforming as well as defining part of humanity. Apart from the truth value and explanatory power of the picture given above, I find the idea beautiful as well as humbling that our journey as an "unnatural" animal began as a result of a little, seemingly unimportant twist of fate, i.e. our bidedalism resulting in tool-use.

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APPENDICES

APPENDIX A: TÜRKÇE ÖZET

İnsan eli Antik Yunan'dan başlayarak ilgi nesnesi olagelmiştir ve kimisi, maharetli olan elin varsayılan insan zekasıyla olan ilişkisinden şüphelenmiştir. Elinizdeki tezin konusu aşağı yukarı budur. İnsan eli ve araç kullanma becerisi insan zihninin evriminde etkili olmuş mudur; olmuşsa hangi şekillerde olmuştur? Bu soruları cevaplamak için araç kullanmadaki birtakım elementlerin başka davranışlarda bulunup bulunmadığına bakılacak, yani ortak noktalar araştırılacaktır. İlk olarak, bu konuyu tartışanlar Anaksagoras ve Aristoteles olmuştur. Anaksagoras, insan ele sahip olduğu için zeka kazandığını savunurken; Aristoteles tam tersini iddia etmiştir: insan zeki olduğu için becerikli el sahibidir. Doğal olarak bu tartışma bu çeşit keskin iddialarla değil daha detaylı bir soruşturma ile yapılabilir. Ama en baştan kabul etmek gerekir ki insan eli ve zekasının evrimi arasında birbirini destekleyen bir ilişki olmalıdır.

İnsan zihninin kökeni gibi bir soru birçok değişik şekilde cevaplanabilirdi, öyleyse neden insan elinin önceliği var? Burada, neyin dikkat çekici bir şekilde farklı olduğuna bakmak gerekiyor. Böyle yaptığımızda bir çift maharetli el ve sayısız araç görüyoruz. Öyleyse el ve araç kullanımı zihnin evriminin sebepleri olabilir. Elbette zihinsel evrimi topyekûn bir mesele olarak değil de onu çeşitli özelliklerinin araç kullanmayla olabilecek bağlantıları üzerinden tartışabiliriz.

Burada metodoloji bakımından bahsedilmesi gereken önemli bir nokta da bu çalışmada uyarlanımcı (adaptationist) evrimsel biyolojinin yoğunlukla kullanıldığıdır. Bu görüşe göre doğal seçilim evrim mekanizmasındaki en önemli itici güçtür. Fakat bu bakış açısı rakipsiz değildir. Geleneksel evrimsel biyolojinin her ne kadar parçası olsa da, bu akıma önemli eleştiriler getirilmiştir. Bunlardan en önemlisi ise bir organın görevi ile onun ortaya çıkış sebebini birbirine karıştırma eğilimidir. Buna rağmen, teorinin zayıf noktalarına da dikkat etmekle birlikte, uyarlanımcılığın en açıklayıcı bakış açısı olduğu kanaatindeyim.

İnsanoğlu öncelikle iki ayakla hareket eden tek canlıdır. Bu konu her ne kadar önemsiz gözükse de, ellerin–daha doğrusu kolların–artık hareketin bir parçası olmayışı onların herhangi bir görev için hazır olduğu anlamına gelir. Aslına bakılırsa, iki ayaklılığın ortaya çıkışını araç kullanmaya yönelme olduğunu savunanlar olmuştur. Fakat, görünen o ki araçlar iki ayaklılıktan çok daha sonra ortaya çıkmışlardır.

İki ayaklılığın dışında insan elinin kendisinin fizyolojik yapısının da araç kullanımına göre evrimleştiği söylenebilir. Bir kere, başparmağın boyunun diğer parmakların boyuna oranı, diğer maymunlarla kıyaslandığında araç kullanımı için çok daha uygundur. Ayrıca insan başparmağı kuvvetli ve nispeten daha kaslıdır ve araştırmalar göstermiştir ki bu derece kuvvetli başparmak araç kullanımını takiben evrimleşmiştir.

İnsan elinin farklılığı yalnızca fizyolojik olmakla kalmaz, aynı zamanda nörolojiktir de. İnsan eli incelikli bir nörolojik sistem ile insan beynine bağlanmıştır. Piyano çalan, klavye kullanan ya da kukla oynatabilen eller bu bağlantı sonucu vardır. Bir ilişkili özellik gelişmiş el-göz koordinasyonudur. Bu özellik sayesinde bu derece incelikli araç kullanımı mümkün olabilir ve bu derece incelikli oluşu çok muhtemel araç kullanımına dayanan hayat koşullarının şekillendirdiği seçilim sonucudur.

Araç kullanımı insan elini tanımlar niteliktedir. Ama diğer hayvanlar da araç kullanımı davranışı göstermektedir. Bu sebeple insanlar için araç kullanımını tanımlamak her ne kadar kolay olsa da diğer hayvanları da içeren bir tanım üretmek hiç de o kadar kolay değildir. Tarihsel olarak çeşitli tanımlar verilmiş olmakla beraber üzerinde anlaşılan noktalar gövdeden bağımsız bir objenin çevreyi manipüle etmekte kullanılması olmuştur. Fakat elbette akla neden sonuç ilişkisi kurmak gibi araç kullanımını tanımlamakta kullanılabilecek faktörler de gelmektedir ve tam bu noktada insan araç kullanımı ile diğer hayvanlar arasındaki fark görünür hale geliyor. Öncelikle karşımıza, diğer hayvanların araç kullanımını incelenirken insan-merkezci bakışın yanıltıcı olabileceği çıkıyor. Yani hayvanlara insan davranışı atfetmek.

Örneğin, böceklerin araç kullanımında nedensellik ilişkisinin açıkça kurulmasını ya da aydınlanma anı yaşanması beklemeyiz, her ne kadar dışarıdan bakıldığında öyle görünse de.

İnsan araç kullanımının ne zaman başladığını tam olarak belirlemek mümkün değil. Homo cinsi ortaya çıkmadan, atalarında böyle bir davranışın zaten mevcut olması da yüksek bir ihtimal. Fakat üretilmiş olan araçlar günümüze kalmış durumda, bu yüzden ilk araç üretiminin ne zaman olduğunu tahmin edebiliyoruz. İlk el baltaları yaklaşık olarak 2.6 milyon yıl öncesinde üretildi; bu devre Oldowan endüstrisi diyoruz. *Homo habilis* bu devirde yaşadı. Bunu daha gelişmiş bir çağ olan Acheulean endüstrisi takip etti ve bu devirde *Homo erectus* hüküm sürdü. Bu araç üretimi çağlarında gözlemlenen devrimsel olan gelişme ise taşı yontarak kesici bir uç üretme fikrinin ortaya çıkışıydı. Çünkü bu fizik yasalarının anlaşılıp, çevrede istenen bir değişim yaratmak için, onlara göre objelerin şekillendirildiği anlamı taşıyordu. İnsan zihninin kökenlerini araç kullanımında aradığımızı söyledik. Öyleyse neden araç kullanan diğer hayvanlarda da en azından görünüşte de olsa bir sıçrama olmadığını açıklayabilir miyiz? Birçok araştırmacı insan araç kullanımını geri kalan hayvanlarınkinden ayırma eğiliminde. Vaesen, örneğin bu bağlamda 9 ölçüt ileri sürüyor: gelişmiş el-göz koordinasyonu, vücut şeması esnekliği, nedensel düşünme, işlev sunumu (representation), yürütücü kontrol, sosyal öğrenme, öğretme, sosyal zeka ve dil. Bu kriterler sınırlayıcı olmamalı. Ayrıca, sosyal öğrenme, sosyal zeka, öğretme ve dilin bağlantılı ve iç içe ele alınması da teklif edilebilir.

Tallis de insan araç kullanımını diğer hayvanlardan ayırt edecek faktörler olduğunu düşünmüştür. En başta hayvanların kullandıkları araçları tekrar kullanmadıklarını gözlemledi. Yani bir şempanze ağaç kovuğunda karınca avladığı dalı saklayıp tekrar kullanmıyor. İnsanlar ise ürettikleri aracı eşya kavramı içerisinde saklıyor ve tekrar kullanıyor. Bunun yanında hayvanlar ürettikleri değil, buldukları nesneleri kullanıyor. Yani gerçek bir üretim süreci söz konusu değil. Fakat bu üretim süreci asıl önemli kısım; çünkü bir fizik kuralının, bir ilkenin nesneye yerleştirilmesi asıl devrimsel olan tarafıdır. Diğer bir fark ise hayvanların ikincil araç üretimi yapmayışı; yani hayvanlar araç üretmek için araç kullanma gibi bir uğraşa girişmiyorlar.

Reynolds da bence önemli olan bir farklılığı vurguluyor: hayvanlar birden fazla parçadan oluşan araçlar yapmıyorlar. Reynolds bu çok parçalı nesnelere *polylith* diyor. *Lith*, Latince taş demek ve *lith*ler dağılmadan 360 derece döndürülebilirler. Örneğin, bir kurşun kalem lith iken, üst üste dizilmiş madeni paralar bir *lith* ya da *polylith* değildir. *Polylithler interlith* aracıyla birbirine sabitlenmiş ve aynı bir *lith* gibi dağılmadan döndürülebilme özelliğine sahiptir. İnsanlar birden fazla parçayı birbirine sabitleyerek araçlar yapıyorken, şempanzeler örneğin yalnızca yer çekimini kullanarak bunu başarabilirler.

Reynolds'un bu araçlar için söylediği özellik dil için de geçerli. Kendisi de bunun dilde de gözlemlenebilir olduğunu vurguluyor. "Cadillac'ın sahibi" örneğinde, iki bağımsız *lith* olan "Cadillac" ve "sahip" kelimelerinin birleşiminden oluşuyor. Her ne kadar gramer kuralları dilden dile farklılık gösterse de, dil baskın olarak çeşitli birimlerin birleştirilerek daha geniş anlamlar ifade edilmesi esasına dayanır. Dil ve araç kullanımı arasındaki bu benzerlik yüzeysel olmayabilir ve uzay kavramı çerçevesinde bağdaştırılabilir. Levinson, uzay algısının tüm diğer algısal verilerin çevrildiği bir temel olabileceğini düşünüyor.

Araç kullanımı farklı çerçevelere de oturabiliyor; bunlardan biri de Gibson'ın kurguladığı gibi dil ve sosyal organizasyonla olan ilişkisi. Bu açıdan önemli bir davranış da taklit. Taklit araç kullanımı için çok önemli bir davranış biçimi, çünkü teknik de denilen araç kullanım formları ancak bu şekilde aktarılabiliyor. Gibson ayrıca araç kullanımı, dil ve sosyal organizasyon arasındaki bağlantının bunlar arasında ortak nörolojik ve bilişsel katmanlar sayesinde olabileceğini de savunuyor. Örneğin, hem dil hem de araç kullanımı hiyerarşik bir yapı sergiliyor. Başka bir dil el ilişkisi ise dilin kökeni noktasında kuruluyor. Zira dilin el jestlerinden ve dolayısıyla araç kullanımından türediğini iddia edenler var.

Dil ve jestler arasında kurulan en sağlam ilişki ise ayna nöronların keşfiyle oldu. Bu nöronlar yalnızca bir el ile jest gerçekleştirildiğinde değil, aynı zamanda bu jest gözlemlendiğinde de etkinleşiyorlar. Dil ile olan ilişkisi ise Makak maymun beynindeki F5 isimli alanın insan beynindeki Broadman 44 adlı alanın türevi olduğunun fark edilmesiyle kuruluyor. Yani el ile gerçekleştirilen işlemler için kullanılan bir alanın, sonrasında dil için özelleşmiş olabileceği görülüyor.

Arbib de taklit kavramı çerçevesinde dil ve araç kullanımının ilişkilendirilebileceğini düşünüyor. En başta hem dilin hem de araç kullanımında bir eşlilik şartının karşılandığını vurguluyor; yani en az iki birey tarafından gerçekleştirilebilir. Takliti ikiye ayırıyor ve bunları, basit ile karmaşık taklit diye adlandırıyor. Arbib'e göre, hayvanlar basit, insanlar karmaşık taklit kullanıyor; insanlar çok daha derin hiyerarşileri kavrayıp taklit edebiliyorlar. Bence, araç kullanışımızdaki giderek artan karmaşıklık bizi karmaşık operasyonlarla başa çıkabilme yetisiyle donattı; bunlar aynı zamanda dil ve düşünce için esaslı kavramlar.

Zeka konumuz için oldukça önemli olmakla beraber bir o kadar da netameli bir nokta. Zeka önemli bir kavram çünkü en azından insanın biyolojik tarihi bakımından, araç kullanımına da bağlı olarak bir gelişmeden bahsetmek istiyoruz. Fakat aynı zamanda ciddi bir insanmerkezcilik tehlikesiyle karşı karşıyayız. Yani insanın çevreyle başa çıkma yöntemlerini türler arası bir standart olarak belirliyor olabiliriz. Örneğin, bir dalı karınca avlamak için kullanan bir şempanzenin davranışı, arıların yön bulma yöntemlerinden daha "zekice" geliyor olabilir. Bu önyargı bu açıdan sakıncalı bulunabilir ve en doğrusunun hayvanlar arası böyle bir kıyaslamaya gidilmemesi olduğu söylenebilir. Ya da bu araştırmanın doğasında insanmerkezciliğin bulunduğu kabul edilip, bu araştırmadan neler öğrenilebileceğine odaklanılır.

Genel kabule göre, omurgalıların omurgasızlardan, memelilerin kuşlardan ve insanın tüm hayvanlardan zeki olduğu varsayılır. Bu varsayım da öğrenme becerileri, problem çözme, esneklik ve yenilik oranları gibi verilere dayanır. Elbette, bu kavramların da çok rahat bir biçimde insanmerkezci olduğu savunulabilir.
Roth ve Dicke tarafından yapılan bir araştırmada yukarıda verilen kabule göre zeka ve beynin özellikleri arasında bir ilişki kurulup kurulamayacağını araştırılıyor. Öncelikle, beyin büyüklüğüne bakılıyor ve kısa sürede bunun bir ölçüt oluşturamayacağı anlaşılıyor. Daha sonra vücut ağırlığına oranla beyin büyüklüğü inceleniyor ve bu ölçümün de yetersiz kalacağı görülüyor. Daha sonra araştırmacılar

korteks kalınlığının bir ölçüt olup olamayacağına bakıyor ve bu noktada anlaşılıyor ki korteks kalınlığı nöron sayısını ve nöron sayısı da sinaps sayısını belirliyor. Sinaps sayısı ise pekala zeka ölçümünde kabul edilebilir bir ölçüt olabilir. Örneğin, kedilerin beyni köpeklerin beyninden daha küçük olmasına rağmen, kedilerin korteks kalınlığı daha fazla olduğu için daha yüksek sayıda sinaps beklenmelidir. İnsan ise ölçülen hayvanlar içerisinde en kalın kortekse sahiptir ve bu sebeple en yüksek Bilgi İşlem Kapasitesine (Information Processing Capacity) sahip olduğu söylenebilir.

Roth ve Dicke beyne yönelik yapılan incelemenin o ya da bu şekilde sınırlayıcı olduğunu kabul ediyor ve bizi açık fikirli olmaya davet ediyor. Onlara göre, insan zihni yalnızca sinaps sayısı gibi sayısal verilerle değil; niteliksel olarak farklarla da ayırt edilebilir. Bunlardan bir tanesi daha önce de bahsi geçen taklit. Taklit öğrenme davranışı için yüksek öneme sahip. Roth ve Dicke aynı zamanda sintaktik-gramatik dil ve zihin teorisi öne sürüyor. Bu iki özelliğin de insan zihnine paha biçilmez katkıda bulunduklarını biliyoruz. Fakat unutmamak gerekir ki bu yollar insan evriminde ortaya çıkmış ve organizmaya özgü çevreyle baş etme yöntemleri ve tarafsız bir zeka kavramının parçası sayılmamalı. Ancak temel sorun hala devam etmekte: zeka anlamlı bir kavram olabilirse, neden meydana gelmelidir?

Bir diğer mesele ise, beyinle de bağlantılı olarak, insan beyninin lateralliği. Corballis, örneğin, insan beyninin lateralliğinin ve yarıküreler arası tercihin insan evrimindeki en önemli aşamalardan biri olduğuna inanıyor. Fakat bildiğimiz önemli bir durum var ki o da insan beyninin tek lateral beyin olmadığı. Fakat, insan laterallikle bağlantılı bir özelliğe sahip: o da tercihen bir eli kullanışı, bu da genellikle sağ el. Tahmin edilebileceği üzere, el tercihi araç kullanımında merkezi bir öneme sahip. Çoğu zaman bir el cismi sabitlerken, diğer el işlemi görür. Buna güzel bir örnek çekiçle çivi çakmak olabilir. Zayıf el çiviyi sabitlerken kuvvetli el de çekiçle vurma işlemini görür. Bildiğimiz bir diğer gerçek ise primatlarda el tercihi gibi bir durumun olmadığı ve maymunların da ancak insanların yanında kullanmayı öğrendikleri araçlarda el tercihi geliştirdikleri görülüyor ama vahşi yaşamda böyle bir durum söz konusu değil. Bağlantı başka şekillerde de kurulabilir. Ayna nöronların el ile gerçekleştirilen etkinliklerle dil arasında ilişki kurmamıza yaradığından bahsettik. Şu da fark edilebilir ki dil ve sağ elin aktiviteleri sol yarıkürede yoğunlaşır. Elbette, sol elini kullanan bireyler de var ama sol taraf için bir eğilim olduğundan bahsedebiliriz. Ayrıca beyin oldukça esnek bir organ. Çok güçlü olmamakla birlikte, laterallik, el tercihi ve araç kullanma arasında bu çeşit bir ilişkiden bahsedilebilir. Yine uyarlanımcılara getirilen eleştiriyi de hatırlayabiliriz, her adaptasyon bir işlev için ortaya çıkmış olmayabilir, yani laterallik, belirli bir çeşit de olsa, araç kullanımından bağımsız bir şekilde ortaya çıkmış olabilir.

El ve araç kullanımına dair tartışmaları tamamladıktan sonra, zihinde gerçekleştiğini iddia ettiğimiz dönüşümlerden bahsedebiliriz. Elbette, bu noktada akla sayısız nokta gelebilir, yani araç kullanımı zihinde pek çok şeyi dönüştürmüş olabilir. Zor olan başka bir şey de, zihin çok fazla sayıda görevi yerine getirdiği için bunları birkaç temel operasyon altında toplamak. Ben yine de iki tane önemli gördüğüm ve araç kullanımı ile bağlantılı olduğunu düşündüğüm özellikten bahsedeceğim: uzay algılayışı ve nedensel düşünme.

Araç kullanmayla ilişkilendirmek üzere uzay kavramından bahsedişimiz açık olmalı. Bir aracın uzay-zaman içinde etki ettiği nesneye göreceli olarak konumlandırılışı ve aracın kendisinin tasarımı ancak ve ancak uzay kavramının yapısına göre belirlenebilir. Nedensel düşünce ise hiç şüphesiz araç kullanımı ile doğrudan ilişkili ve maharetli bir biçimde araç üretme ve bunu esnek bir şekilde kullanmak güçlü bir nedensel düşünebilme yetisine işaret eder.

Uzay kavramından başlarsak, akla ilk gelen kavramın fiziksel anlamları olacaktır. Uzay kavramı öncelikle Newton ve Leibniz arasında bir tartışma konusu olmuştur. Newton uzayın mutlak bir yapısı olduğunu iddia ederken, Leibniz onun göreceli bir kavram olduğunu düşünmüştür. Bugün ise, Einstein'dan sonra uzay kavramı fizik bilimi açısından sokaktaki insan fikrine hitap etmekten çıkmıştır. Benim asıl uzay kavramı çerçevesinde tartışmak istediğim düşünür ise Kant. Kant, *Arı Usun Eleştirisi*'inde Transendental Estetik adlı bölümü uzay ve zaman tartışmasına ayırmıştır. Ona göre, bu iki kavram da zihinden bağımsız olmayan kavramlardır ve duyu organlarıyla alınan verileri anlaşılabilir kalıplara sokarlar. Bu bakımdan, gerçekte algılarımız dışındaki dünyanın nasıl bir yer olduğunu bilmemiz mümkün değildir. *Arı Usun Eleştirisi*'nin temel amacı bilinebilirliğin sınırlarını çizmektir ve bahsedilemeyecek olanları yani *kendinde-şey*leri işaret etmektir. Kant uzay kavramını açıklarken öncelikle onun ampirik bir kavram olmadığını kanıtlamaya gayret eder. Bunu yaparken öncelikle bizim nesneleri kendimizin dışında bulunmak kaydıyla sunduğumuzu söyler. Bu nesneler *yan yana* bulunurlar. Daha sonra Kant der ki, bizim nesneleri yan yana, uzay içinde resmedebilmemiz için en başta uzay kavramına ihtiyacımız vardır. Yani bunu çevremizden öğrenemeyiz. Kant ayrıca uzayı tamamen boş bir biçimde tasavvur edebilirken, bir nesneyi uzay içinde bulunmadığı halde resmedemeyiz. Burada dikkat etmemiz gereken nokta, Kant'ın uzay kavramının nasıl da birbirinden ayrılmış nesneler üzerinden tanımlandığını görüyoruz. Öncelikle, nesneleri yan yana algılama özelliğinin uzay fikrinin bir parçası olduğunu söylemiştir. Daha sonra ise bir nesneyi uzay olmadan algılayamayacağımızı. Fakat biliyoruz ki bir nesnenin sınırları belirlendiği anda yani sınır çizildiği takdirde uzay kendiliğinden takip edecektir. Yani, her ne kadar Kant kendisi söylemese de uzayında nesneler tanımlayıcı bir rol oynar. Bence uzay ve nesne kavramları beraber tanımlanmalıdır.

Bu nesnelerin birbirilerinden ayrı olarak uzay içinde resmedilmesi Reynolds'un insanın araç kullanımındaki farklılıkla benzerlik taşır. Reynolds lithlerden bahseder ve bu lithler esnek bir biçimde bir araya getirilebilir ya da ayrılabilir. Yukarıda bahsedilen uzay anlayışında da nesnelerin birbirilerinden ayrılmış bir şekilde sunulması tartışmaya açılmadan verilmiştir. Dolayısıyla, insanlarda bu çeşit bir uzay anlayışı yaygın araç kullanımına bağlı olarak gelişmiş olabilir.

Sayı sayma, örneğin bu duruma iyi bir örnek oluşturabilir. Sayı sayarken nesnelerin birbirilerinden farklı ve ayrılmış oluşunun belirlenmiş olması esastır. İnsanlar bu işi beceriyle gerçekleştirebilir. Yine şaşırtıcı olmamakla birlikte insan türü sayı sayan tek hayvan olabilir, zira bu konuda bazı deneyler birtakım hayvanların da sayı sayabileceğini gösteriyor. Fakat konu tamamen açıklığa kavuşturulmuş değil.

Benzer şekilde işaret etmenin de benzer bir uzay algısının ürünü olduğu söylenebilir. Henüz bir yaşını doldurmamış ve dil aşamasına geçmemiş bebeklerin nesnelere işaret ettikleri gözlemleniyor. Önce çeşitli sesler çıkararak rahatsızlık bildiren bebek, daha sonra arzu edilen nesneye işaret ediyor. Herhangi başka bir türde işaret etme gözlemlenmemiş. İnsanların ise bu kadar erken yaşta bunu gerçekleştiriyor olmaları, onların uzayda nesneleri ayırt etme konusundaki eğilimlerinden kaynaklandığı söylenebilir.

Bu çeşit bir uzay anlayışının gözlemlenebileceği bir başka yer ise dil. Daha evvel bahsettiğimiz gibi Reynolds bağımsız birimleri birleştirerek yeni bir birim üretebilme kabiliyetini yalnızca araç kullanmada değil aynı zamanda dilde de görüyor. Bu sebeple "Cadillac'ın sahibi" örneğini vermiştik. Dile bu benzeri bir yaklaşım aynı zamanda Chomsky'de de var. Minimalist Programı'nda *birleştirme operasyonu* (Merge operation) dediği bir şey ortaya atıyor: Reynolds'ın fikrinden çok da farklı değil. Chomsky'e göre bu operasyon, küçük birimleri birleştirerek daha büyük yapılar oluşturmaya yarıyor. Bu açıdan dil ile araç kullanımını bağdaştırmak oldukça mümkün.

Dil ve araç kullanımı arasındaki bir başka paralellik de özyineleme (recursion). Corballis özyinelemenin kendi başına insan zihninde devrime yol açtığını iddia ediyor. Özyinelemeyi biz en çok dilde, matematikte ve geometride görüyoruz. Corballis, zihin teorisinin dahi özyineleme olmadan mümkün olamayacağını söylüyor. Özyinelemenin görüldüğü bir başka durum ise araç kullanımı ve üretimi. İç içe makineler, devreler kuruyoruz. Özellikle dikiş ve sepet yapımında özyinelemeli düşünce görülüyor. Bu bakımdan dilde ve düşüncede baskın yere sahip olan özyinelemenin, yoğun araç kullanımının zihni hiyerarşik yapılarla zorlaması sonucu ortaya çıktığını söyleyebiliriz.

Ayrıca bazı araştırmacılar hareket sıralama (action sequencing) ve sentaksın bağlantılı olabileceğine inanıyor. Bunun yanında, isabet alarak atma–yani dart atmak ya da meyve düşürmek için taş atmak gibi–ile dilin evrimi arasında bağlantı kuranlar da var. Bu araştırmaya göre isabetli atıştaki sıralayıcı nörolojik mekanizma daha sonra dil için özellikle sentaktik görevlerde kullanılmış olabilir.

Araç kullanmanın insan zihninde gelişimine sebep olduğu bir başka mekanizma ise nedensel düşünme olabilir. Nedensel düşünme, araç kullanımı ve üretimi başta gelmek üzere zihinsel dünyamızın temellerinden biridir. Diğer hayvanlar her ne kadar araç kullanma davranışı gösteriyor olsalar da nedensel düşünme biçimine sahip olmayabilirler. Bu durumu göstererek nedensel düşünme insanda ortaya çıktığını ve bunun temel sebebinin araç kullanma olduğunu söyleyebiliriz.

En başta yapmamız gereken alışkanlıktan gelen öğrenmeyle gerçek nedensel düşünceyi birbirinden ayırt etmek. Buna göre, örneğin bir kedi yiyeceğe ulaşmak için manivelayı kaldırmayı öğrenebilir, ya da bir şempanze karınca avlamak için bir çubuğu kullanabilir. Ama gerçekten de neden-sonuç ilişkisini kurgulayıp kurgulamadıklarını bilebilir miyiz?

Elimizdeki ilk önemli veri insan harici hayvanların ciddi anlamda araç kullanma davranışı göstermedikleri yönünde. Bu da nedensel düşüncenin gelişmiş olmadığına işaret edebilir. Burada belirginleşen önemli bir sorun da teknoloji ve nedensellik arasındaki ilişki. Yüzeysel açıdan bakıldığında sorunsalı tavuk-yumurta meselesine benzetebiliriz ama bence en doğrusu artan teknolojik baskının sebep olduğu zihinsel dönüşüme odaklanmak. Yani araç endüstrisi asıl zihinsel dönüşümü tetiklemiştir. Bunun da diğer hayvanlarda mevcut olmadığını düşünürsek, nedenselliğin bulunma ihtimali de zayıflayacaktır.

Bir araştırmaya göre, en yakın akrabalarımız olan primatlarda neden-sonuç ilişkisi kurma kabiliyetinin pek de bulunmadığı belirleniyor. Bu da bize doğal kuvvetler hakkında çok az bilgi sahibi olduklarını gösteriyor. Bildiğimiz bir başka durum ise, bir anne şempanzenin yavrusuna ceviz kırmayı öğretmesi 5 yılı buluyor, bu da bize yine zayıf bir nedensellik algısına sahip olduklarını gösteriyor. Yine aynı araştırma, henüz birkaç aylık olan bebeklerin sabit ya da hareket eden katı nesnelerden oluşan bir dünya fikri oluşturduklarını ve bu çeşit bir kavramsallaştırmanın yavaş yavaş kuvvet kavramına dönüştüğünü söylüyor. Bu fikrin bu kadar erken yaşta ortaya çıkmış olması, insanların nedensellik fikrine eğilimli bir şekilde dünyaya geldiklerini destekliyor.

Özetle, bu çalışmada insan eli ve araç kullanımı ile ilişkilendirilebilecek geniş bir yelpazeden konular ele aldım. İnsan elinin öyle ya da böyle özel olduğunu ve araç kullanımının insanda ne kadar farklı şekillerde ortaya çıkabileceğini anlattıktan sonra, insan zihninde meydana gelmiş olabilecek farklılıklardan bahsettim. Bunlar; uzay algısı ile buna bağlı olarak değerlendirilebilecek dil ve teknolojiyle oldukça ilişkili olan nedensellik. Tabii ki elin ve araç kullanmanın etkileri bunlarla sınırlı kalmayabilir zira insan zihni bizi her zaman şaşırtabilir.

APPENDIX B

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı :
Adı :
Bölümü :

TEZİN ADI (İngilizce) :

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: